

# **FINAL REPORT**

**From the Executive Task Force on**

## **BIOMASS and BIOFUELS DEVELOPMENT in KENTUCKY**

**A collaborative effort of the Governor's Office of  
Agricultural Policy and the Energy and Environment  
Cabinet**

**December 10, 2009**

## **The Charge to the Task Force:**

**Facilitate the development of a sustainable biomass and biofuels industry in Kentucky that will generate prosperity in a carbon-constrained environment, and revitalize rural Kentucky by creating new jobs and strengthening local economies.**

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## Membership

In August 2009 Governor Beshear issued an Executive Order forming the Governor's Executive Task Force on Biomass and Biofuels Development in Kentucky. The following persons were appointed as members:

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## Executive Summary

In August of 2009 Governor Steven L. Beshear convened an Executive Task Force on Biomass and Biofuels to establish strategic actions to develop a sustainable biomass and biofuels industry in Kentucky. Governor Beshear recognized the need to diversify Kentucky's energy portfolio and to provide economic prosperity to rural Kentucky. The Task Force built on existing biomass and biofuel goals and recommendations established in Kentucky's energy plan, *Intelligent Energy Choices for Kentucky's Future*; the Kentucky Agriculture Council's *A Pathway for Kentucky's Agriculture and its Rural Communities: 2007 to 2012 Strategic Plan*; and the Kentucky Renewable Energy Consortium *bioenergy Roadmap for Kentucky* to formulate a single plan of action for the Commonwealth.

To develop the plan, the task force studied existing as well as future supply and demand for biomass and biofuels in Kentucky. The federally mandated Renewable Fuels Standard (RFS) is driving the demand now and will drive the demand in the future for biofuels. As a result of this standard, Kentucky consumers now use 10 percent biofuels in over 70 percent of their gasoline. However, only 24 percent of the biofuels currently consumed is produced in-state with the balance being imported primarily from the Midwest. As the mandate expands over the next 13 years, the average biofuels blend rate will increase to over 25 percent further increasing Kentucky's need for biofuels imports. This will increase Kentucky's demand for biofuels from 150 million gallons to 775 million gallons per year. Since the RFS limitations of biofuels from food crops such as corn have already been met, Kentucky's biofuels production will likely come from forestry products and energy crops. If Kentucky fails to expand its biofuels production, the Commonwealth will import nearly 90 percent of its renewable fuels in 2022, the final year of RFS expansion.

The demand for renewable electricity is driven, in part, by Renewable Portfolio Standards (RPS). Twenty seven states and the District of Columbia have mandated that utilities generate a percentage of their electricity sold from renewable sources. The United States House of Representatives passed the *American Clean Energy and Security Act*, which includes a federal renewable and efficiency portfolio standard that calls for 20% of electricity demand to be met through renewable energy and energy efficiency by 2020. A portion of this, up to 40 percent, can be met through efficiency upon request of the Governor. This standard would be in effect through 2039. If efficiency is maximized, by 2025 Kentucky will need to produce 12 percent of its electricity from renewable sources, buy the renewable electricity credits generated in other states or pay penalties.

Given the limited availability for other renewable resources—solar, wind, hydropower and geothermal—in this region, it is expected that if Kentucky meets the standard by generating electricity from renewable sources in state it would do so primarily by co-firing with biomass. If Kentucky doesn't develop renewable electricity, it will compete against other states for limited renewable electricity credits, which will increase electricity rates without receiving the economic benefits of developing its own renewable electricity.

If Kentucky chooses to proceed with the development of biomass-based biofuels, approximately 10 million tons of biomass will be needed to produce 700 million gallons of renewable biofuels. Should Kentucky be required to adopt a 12 percent federal RPS and choose to meet the RPS through in-state renewable energy production, approximately 15 million tons of biomass will be used for combustion. The combined demand for biomass resources from Kentucky's forests and farmland for the generation of electricity and the production of biofuels approaches 26 million tons, compared to current in-state coal demand of 44 million tons. Such demand not only requires full productivity from Kentucky's forests, but provides farm diversification opportunity. The Task Force concludes that 25 million tons of biomass per year, produced within a sustainable environment defined by the Commonwealth with land use changes involving 15% of Kentucky's farmland, is feasible by 2025 if improvements in yield and adaptability are realized.

Producing the supply Kentucky will need to meet demand is no small task. Kentucky will need to invest in research to select the feedstocks that generate the most output from Kentucky land in the most sustainable way. Kentucky will need to plan for logistical challenges relating to moving biomass to be processed, densified and utilized. Furthermore one of the most common processes to use biomass to produce electricity is co-firing with coal. However, existing coal-fired power plants that co-fire with biomass may require re-premitting and retrofits to meet emission standards.

The bioenergy industry must address the challenges it faces and one strategy to do this is by adopting New Generation Cooperatives (NGC). NGC members purchase the right to supply the cooperative thereby establishing a steady supply of agricultural inputs required to run operations at the most efficient level. NGC members pool resources to capitalize regional production, densification, handling and processing systems. Though not commonly used in Kentucky, NGCs have been proven successful at creating economic prosperity in small Midwestern communities.

A bioenergy industry will have significant impacts on Kentucky's economy especially in rural areas. It is estimated that biomass production and processing can generate up to \$3.4 billion of net output annually along with 10,000 jobs, much of which will be concentrated within rural communities statewide. If carbon constraints are imposed on Kentucky, electricity generated from biomass will offset electricity generated from carbon-intensive fuels. This will free up carbon credits which could be sold.

The Governor's Executive Task Force on Biomass and Biofuels Development has accomplished a macroscopic analysis of a Kentucky biomass industry, and has served to elevate awareness of the economic and environmental benefits of biomass and biofuels production. In summarizing its findings the Task Force has arrived at five strategic actions as follows which form the basis for recommendations to Governor Beshear:

1. Kentucky must identify a single agency to coordinate biomass and biofuels development efforts.
2. Kentucky must develop policies to mitigate demand risks.
3. Kentucky must develop policies to mitigate supply risks.
4. A biomass industry must be sustainable.
5. Capitalization mechanisms must be developed.

## Introduction

In August 2009 Governor Beshear issued an Executive Order that established a Task Force on Biofuels and Biomass. The Task Force was charged with six specific tasks:

- Validate Kentucky's biomass production capabilities within a sustainable environment
- Validate Kentucky's potential biomass demand
- Evaluate biomass transportation and logistics opportunities, and recommend a course of action
- Evaluate the status of energy crop and forestry biotechnology and genetics, and recommend a plan of action that allows biotechnology to support biomass production
- Evaluate available business structures in Kentucky, including structures that allow direct producer ownership, and formulate plans of action that allow adequate capitalization of a new biomass industry
- Facilitate economic impact analysis of the effect of a biomass and biofuels industry on Kentucky

The Task Force convened its first meeting on September 2, 2009, and through a series of six meetings arrived at its conclusions and recommendations on December 7, 2009, culminating with the presentation to Governor Beshear of its Final Report.

The Task Force followed a pre-outlined work plan (Appendix II) that allowed it to methodically investigate and collect data analyzing the six tasks. By means of both selected and voluntary testimony and presentations, the Task Force accumulated information, held extensive discussion, and developed final recommendations. The Public was notified of all Task Force meetings, and responded with significant attendance, with approximately 100 in attendance at most meetings. A Task Force website has also been developed at [www.energy.ky.gov/biomass](http://www.energy.ky.gov/biomass) where all agendas, minutes and presentations have been posted.

Recognizing the complicated and extensive subject matter associated with bioenergy, the Task Force has not attempted to develop a detailed plan of deployment for biomass and biofuels, but instead has focused specifically on the tasks outlined in the Executive Order, which are essential to building a successful foundation for biomass development. In recognition of the need to continue its efforts, however, the Task Force has also recommended future actions that will be necessary for a detailed roadmap.

This Final Report is sectionalized by Task. The report has been developed by summarizing the testimonies, presentations and discussions, and represents the consensus of the Task Force. For some technical areas such as processing technologies in which time did not allow significant testimony, the Task Force has relied upon information from the *State Bioenergy Primer* published by the Environmental Protection Agency in August 2009, as well as other government and academic sources.

The success of the Task Force has resulted not only from the knowledge and commitment of its members, presenters and staff, but also from the support shown by the businesses and citizens of Kentucky through their numerous phone calls and emails.

## BIOMASS SUPPLY

***“Validate Kentucky’s biomass production capabilities within a sustainable environment.”***

### 1.1 Biomass Overview

Across the country, states are looking for ways to tackle their energy, environmental, and climate change challenges through a variety of approaches. One frequently discussed option is the use of biomass resources to develop bioenergy—bioheat, biopower, biofuels, and bioproducts.

In Kentucky "biomass resources" means any organic matter that is available on a renewable or recurring basis, including agricultural crops and trees; wood and wood residues; plants, aquatic plants, and plant oils; grasses; animal fats and animal by-products; animal manure; residue materials; and waste products (KRS 152.715). This Task Force has confined its discussions to no-food biomass resources.



Biomass energy, or bioenergy—fuel or power derived from organic matter—can be used to produce transportation fuel, heat, electric power, or other products. Bioenergy currently represents approximately 3 to 4 percent of the United States’ total energy production (EIA, 2008).

The benefits of increased use of bioenergy depend upon the intended use and source, but can include improved energy security and stability through reduced dependence on foreign sources of energy; increased economic development and job growth through creation of new domestic industries and expansion of existing industries; and expanded environmental benefits, including reduction of greenhouse gas (GHG) emissions.

Along with the opportunities, however, are potential challenges—among them the need for reliable feedstock supplies, the problems of infrastructure constraints for delivering of feedstocks and distribution of products, the potential for ancillary environmental and land use impacts resulting from increasing biomass supplies to produce bioenergy, and the potential for tradeoffs in air emissions resulting from direct combustion of biomass. (State Bioenergy Primer, EPA, 2009)

### 1.2 Current Biomass Supplies

#### 1.2.1 Agricultural Biomass

Many farmers already produce biomass energy by growing corn to make ethanol. But biomass energy comes in many forms. Virtually all plants and organic wastes can be used to produce heat, power, or fuel. Biomass energy has the potential to supply a significant portion of America's energy needs, while revitalizing rural economies, increasing energy independence, and reducing pollution. Farmers would gain a valuable new market for their products. Rural communities could become entirely self-sufficient when it comes to energy, using locally grown crops and residues to fuel cars and tractors and to heat and power homes and buildings.

Agricultural activities generate large amounts of biomass residues. While most crop residues are left in the field to reduce erosion and recycle nutrients back into the soil, some could be used to produce energy without harming the soil. Other wastes such as manure from poultry and livestock operations can also be profitably used to produce energy while reducing disposal costs and pollution.

Crops grown for energy can be produced in large quantities, just as food crops. While corn is currently the most widely used energy crop, native trees and grasses are likely to become the most popular in the future. These perennial crops require less maintenance and fewer inputs than do annual row crops, so they are cheaper and more sustainable to produce. Switchgrass appears to be the one of the most promising herbaceous energy crops. It produces high yields and can be harvested annually for several years before replanting. Other varieties native to Kentucky that grow quickly, such as eastern gamagrass and big bluestem along with non-native sterile hybrids like miscanthus may also be planted for energy.

Some fast-growing trees make excellent energy crops, since they grow back repeatedly after being cut off close to the ground. These short-rotation woody crops can grow to 40 feet in less than eight years and can be harvested for 10 to 20 years before replanting. In cool, wet regions, the best choices are poplar and willow. In warmer areas, sycamore, sweetgum, and cottonwood are best. Oil from plants such as soybeans and sunflowers can be used to make fuel. Like corn, however, these plants require more intensive management than other energy crops.

With thoughtful practice and management, perennial energy crops can improve the soil quality of land that has been overused for annual row crops. The deep roots of energy crops enhance the structure of the soil and increase its organic content. Since tilling occurs infrequently, the soil suffers little physical damage from machinery. Perennial energy crops need considerably less fertilizer, pesticide,



herbicide, and fungicide than annual row crops. Reduced chemical use helps protect ground and surface water from poisons and excessive aquatic plant growth. Furthermore, deep-rooted energy crops can serve as filters to protect waterways from chemical runoff from other fields and prevent sedimentation caused by erosion.



Perennial energy crops can also create more diverse habitats than annual row crops, attracting a wider variety of species such as birds, bees, and other beneficial insects, and supporting larger populations. The long harvest window for energy crops enables farmers to avoid nesting or breeding seasons. (Union of Concerned Scientists, 2003)

Kentucky has 8.4 million acres of crop land. It is estimated that the state's agricultural community could produce over 2.3 million dry tons of agricultural residue biomass annually. Another 3.6 million dry tons of dedicated energy crops could be produced at \$40/ton. One study estimated that on Conservation Reserve Program (CRP) land alone, 1.8 million dry tons of switchgrass and 1.4 million dry tons of willow and hybrid poplar could be produced each year. Management of farm animal manure could provide an additional 34,000 tons of methane annually. (DEDI, 2008)

Lignocellulosic materials such as switchgrass and crop residues hold great promise for future biofuel production. The potential for Kentucky lies in using crop residues and "other-hay" – hay other than alfalfa. Kentucky currently has 2.15 million acres of land in other-hay with an annual yield of 2.3 tons per acre. Kentucky has a significant source of land available for renewable energy production in other-hay crop land. Assuming that switchgrass could be sold at the same price as hay, 25% of the other-hay land could be converted to switchgrass resulting in a higher income per acre for farmers since the expected yield would be 6 tons per acre. If this 25% conversion took place, 4.5 million tons per year of switchgrass would be available for ethanol production. This scenario could produce 361 million gallons per year of ethanol from switchgrass alone. (DEDI, 2008)

Other crop residues such as corn stover and wheat straw could also be used to produce ethanol. Kentucky's corn and wheat production levels could supply an additional 1.5 million tons per year of residue material with an average ethanol yield of 80 gallons per ton. The total from cellulosic crops would be 121 million gallons per year. (DEDI, 2008)

## 2007 land resources (ac) on Kentucky farms<sup>1</sup>.

<sup>1</sup> [http://www.nass.usda.gov/Census/Create\\_Census\\_US.jsp](http://www.nass.usda.gov/Census/Create_Census_US.jsp)

	Cropland			Woodland	Rangeland	CRP	Total
	Harvested	Pastured	Other				
<b>West</b>	2,899,629	734,671	493,870	1,101,705	471,144	348,264	6,049,284
<b>Central</b>	1,848,973	1,600,940	281,417	1,357,147	967,817	49,987	6,106,281
<b>East</b>	230,380	241,339	76,741	652,758	174,718	5,471	1,381,410
<b>Total</b>	4,978,983	2,576,950	852,031	3,111,610	1,613,678	403,724	<b>13,536,975</b>

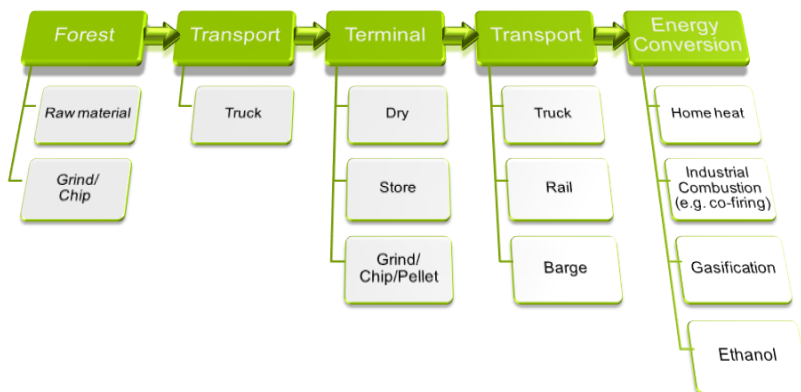
(Shearer, Scott, 2009)

### 1.2.2 Forest Biomass

Initial estimates of woody biomass for meeting Kentucky's future energy needs (Intelligent Energy Choices for Kentucky's Future: Kentucky's 7-Point Strategy for Energy Independence, 11/08) indicated the potential contribution of 9.18 million dry tons per year. Sources of woody biomass included:

- unextracted wood and bark from current timber harvesting (1.95 million dry tons);
- debris from urban sources (0.34);
- material from thinnings and other forest improvement treatments (1.21);
- biomass energy plantings from 25% of acreage not in Conservation Reserve Program (3.78); and
- annual net growth (currently unused) (1.9).

Residues from primary and secondary industries were not included as markets already exist for the majority of this material. The estimates above were developed from sources such as the National Biomass Partnerships using US Forest Service data and other credible sources as well as estimates using US Forest Service Forest Inventory and Analysis and aligned data.



Governor Beshear's energy plan also indicated that Kentucky's forest resource could be jeopardized by over-harvesting and poor management resulting from the emergence of a biomass energy sector, especially as it relates to the use of net forest growth. The energy plan also indicated that careful harvesting and a renewed emphasis on forest management education and land-use policies will be required to avert problems to the forest resource and Kentucky's forest industries.

The estimates of woody biomass availability for energy use (to this point) were developed from broad-brush data and refined estimates are required to ensure the development of an effective energy strategy. This includes estimates of woody biomass availability as well as cost data associated with woody biomass production and/or extraction. More information is needed in the following areas:

- The 3.78 million dry tons from woody biomass plantings may provide room for agriculture biomass crops coming from non-cropped acreage. However, analysis of this potential conflict has not been thoroughly addressed.
- Woody biomass production from short rotation energy plantings is projected to provide a significant portion (3.78 million dry tons) of the total of 9.18 potential contribution. Techniques for producing these plantings have been well developed for highly productive agricultural soils and partially developed for marginal sites. However, harvesting technologies for these plantings on marginal lands (steep agricultural lands, surface mines, etc.) have not been well vetted and yield estimates from this source of biomass must include considerations associated with effective and efficient production and harvesting of these sites.
- Costs associated with the biomass extraction from thinnings and other traditionally noncommercial forest improvement practices have not been thoroughly researched and costs could preclude a portion of this biomass from being used even under liberal biomass price estimates.
- Extracting currently unused wood and bark from harvesting as well as extraction of biomass from thinnings and the extraction of net growth may be environmentally unacceptable on significantly steep slopes in eastern Kentucky (and other areas of the state where soil instability is an issue) and other areas of topographic and biologic concern. Estimates must be revised to consider these situations.

While the estimates of woody biomass assume that biomass will come from sources currently not being used for other purposes, economics will dictate where the biomass actually comes from (assuming no governmental control). The ramping up of a woody biomass industry could easily generate both short and long-term negative impacts to Kentucky's traditional forest industries.

The economics associated with the efficient extraction of biomass move logging firms towards volume production. This normally results in and requires the use of mechanized harvesting and maximizes the amount of harvested material per acre. This requires logging firms to upgrade equipment to use self-propelled harvesting equipment such as feller-bunchers and harvesters. This also requires the use of grapple skidders or forwarders, an upgrade in delimbers, and potentially the purchase and use of chippers and other types of biomass processing equipment. This investment in equipment requires more capital and potential business acuity than is required by small manual chainsaw operations associated with low volume extractions of high quality sawtimber. Currently 10-20 percent of the logging firms are running the set of equipment easily converted to biomass harvests. Certainly there will be logging firms that are capable of adapting as well as those that are not capable of operating at this level of investment and management.



Considering short-term effects on forest industries, it is reasonable to assume that prices paid for woody biomass must provide for reasonable extraction costs and at least marginal profit levels for producers. If this is the case low-valued trees or portions of trees currently extracted and sold as pulpwood (primarily in western and west-central

Kentucky) and other materials currently supporting cant and pallet industries, charcoal, railway ties, and potentially low valued factory lumber could easily be diverted to biomass. Some of these industries are already projecting short-falls in potential resource base and under periods of market competition from a biomass market could easily affect them. The larger the woody biomass market and the faster it develops the greater the short-term effect on forest industries using low-grade, low quality material. These industries are not insignificant and provide important economic inputs to Kentucky.

Long-term effects on forest industries include that biomass markets could potentially impact the long-term production and availability of high quality and high valued timber that is needed for Kentucky's primary sawmilling industry (an industry that can provide the resource for a strong secondary industry with high value added potential). Studies of the introduction of chip markets into traditional hardwood sawtimber territories have indicated a potential reduction in long-term availability of quality sawtimber. This is a result of short-term economic decisions that lead to increased intensive harvesting creating younger age classes and a reduction in older larger age classes. It is reasonable to assume that a vibrant woody biomass market would change the forest industry workforce, its location, and the overall economic input to the Commonwealth. An evaluation of these changes would be appropriate to help plan for maximizing the economic output of our forest industry.

Recent articles and publications from organizations representing non-industrial private family forest owners have indicated the need for biomass markets to improve management of woodlands and small privately owned family forests. Essentially biomass markets have been portrayed as a means of being able to remove low value and low quality trees from woodlands to provide much needed growing space for good growing stock (as well as providing extra income from traditional harvests). However, the economics of the former type of biomass harvesting have not been well investigated and issues associated with scale may easily preclude the use of biomass markets for improving many small woodlands. Economics certainly drive the system towards high volume, highly efficient harvests requiring the removal of more material than can be generated by many traditionally non-merchantable improvement practices. While many woodlands can benefit from markets for the removal of currently unmerchantable material it is unclear if the economics associated with biomass markets will provide viable options for many small woodlands. If the removal is not controlled it could result in a degradation of small woodlands for many of the preferred uses and recurring income stream needed by family forest owners.

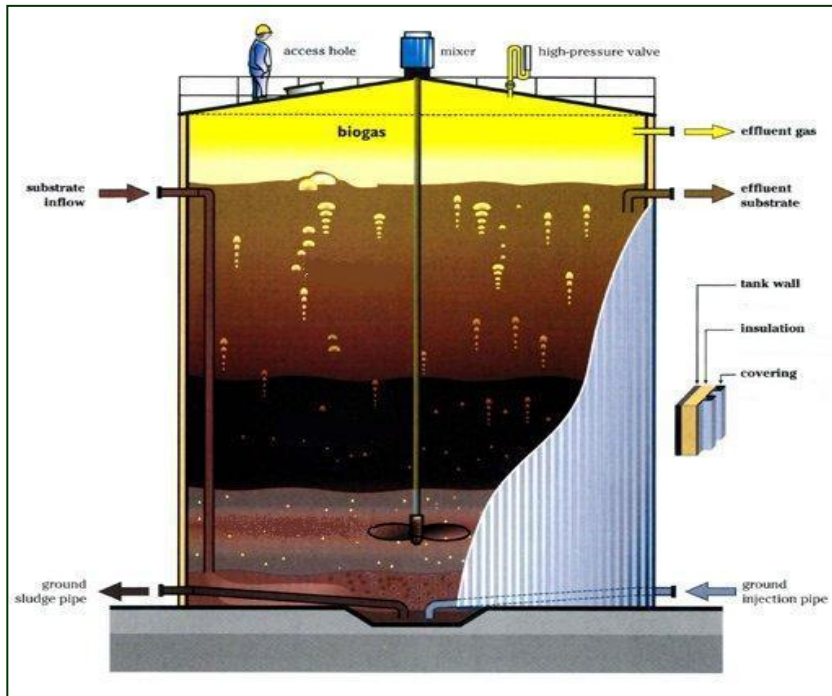
Biomass markets can represent a tool that can be used for the improvement of forests for a number of uses and values. However, economic analysis is needed to determine what types of improvement practices can be supported by biomass markets and develop reasonable estimates of the total biomass available from this source. (Stringer, 2009)

### ***1.2.3 Municipal and Other Biomass***

Municipal solid waste (MSW) power plants burn solid refuse from relatively large urban centers. While this type of power plant can be economically feasible, many concerns have been raised about the environmental safety of burning a multitude of domestic, commercial and industrial waste products. This risk can be mitigated by using relatively homogenous waste streams, such as scrap from manufacturing processes, or by presorting the waste content. Kentucky burns negligible amounts of MSW for the generation of electricity. Research is also progressing on the use of MSW as a feedstock for ethanol and other liquid fuel products.

Landfill gas (LFG) power plants are a variant of MSW technology, where gas from the decomposition of waste is used to fire turbines for electric generation. Municipal solid waste landfills are the second largest source of human-related methane emissions in the United States, accounting for nearly 23 percent of these emissions in 2006. At the same time, methane emissions from landfills represent a lost opportunity to capture and use a significant energy resource. Landfill gas consists of about 50 percent methane, the primary component of natural gas, about 50 percent carbon dioxide, and a small amount of non-methane organic compounds. Using LFG to generate power helps to reduce odors and other hazards associated with LFG emissions, and it helps prevent methane from migrating into the atmosphere and contributing to local smog and global climate change (EPA, 2008). Kentucky has five active LFG power plants and

a sixth project is under construction. The five active sites have a combined generating capacity of 16 megawatts (EPA, 2008b). The state's largest landfill, Louisville's Outer Loop, diverts a portion of its methane gas for direct use in a nearby industrial park. An additional 18 candidate sites and 12 potential sites are identified in the EPA's database. The theoretical potential of these resources could reduce the state's energy consumption by 5.9 trillion Btu (Colliver et al., 2008).



The decomposition that occurs underground in landfills can be engineered using anaerobic digester (AD) systems. Anaerobic digesters, often referred to as methane digesters, are amenable to biomass resources having high moisture contents. Byproducts from organic industrial processes, Kentucky's wastewater treatment facilities, ethanol and distillery manufacturers and livestock operations could be converted into biogas using AD technology. Besides energy production, anaerobic digesters offer other benefits including odor reduction, reduced greenhouse gas emissions, and potential pathogen reductions. (DEDI, 2008)

## 1.3 Sustainability Standards

### 1.3.1 Forestry

The economics associated with biomass extraction can lead to complete extraction of all of the above ground parts of trees that are cut for traditional markets as well as the cutting of trees of smaller diameter. Taken to the ultimate conclusion this results in complete or nearly complete clear cutting with the harvesting of trees greater than 3 to 4 inches in diameter. Further, when whole trees are skidded to the landing (a common practice when biomass is being extracted from sawtimber and pulpwood harvests) the duff layer (leaves and organic matter on top of the soil) is incorporated (mixed) into the mineral soil, essentially producing exposed mineral soil. Also this type of skidding can damage and reduce the number of small seedlings and saplings left after a harvest. These effects when spread over entire woodlands or landscapes can result in the following ecological concerns:

- Extraction of leaves, current year's growth, and branches (tree tops) can result in the loss of nutrients potentially leading to long-term productivity loss. Loss of small seedlings and saplings can result in the reduction of regeneration of native species such as oaks that require advance regeneration (seedlings and saplings established before harvesting). Exposed mineral soil results in the regeneration of native species that easily reproduce from seed at the time of harvest (ex. yellow-poplar, pines). The end result is an increase in species that commonly reproduce directly from seed after a harvest or disturbance and a loss of species that require advance regeneration (some that are of significant importance biologically and economically). Ultimately this species shift will have impacts on the long-term species composition of our forests, overall bio-diversity, and will have ramifications for our forest industries.

- The exposed mineral soil provides opportunities for the invasion of exotic plant species. Some of these exotic species have significant potential to displace valuable native species and reduce overall bio-diversity.



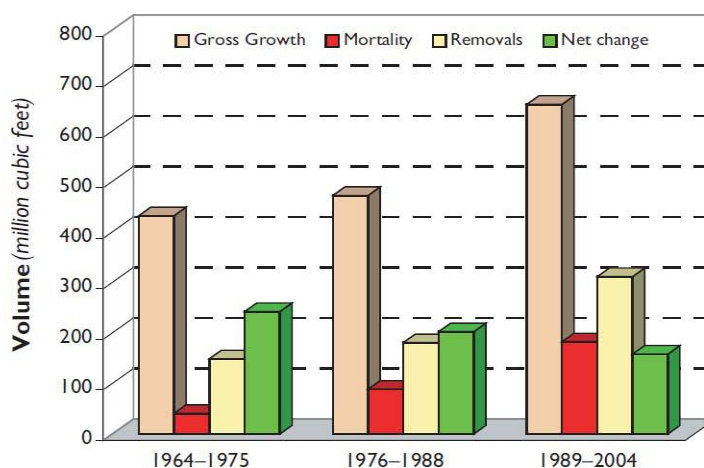
- Changes in habitats associated with biomass clear cutting will negatively affect species requiring intact forests (ex. interior bird species) and those requiring sheltered and shaded environments (ex. salamanders, understory wildflowers). Increases will occur in species that favor drier habitats and those requiring open forests with young age classes some of which are invasive. All of these habitat changes will ultimately impact wildlife populations.

As indicated by Kentucky's energy strategy, forest health and long-term ecological integrity must be maintained. It is reasonably clear that some type of control(s) would be required to ensure sustainable extractions of biomass from forests. There are several mechanisms that could potentially work alone or in concert to help ensure sustainable use of woody biomass as follows:

- Restriction of biomass harvests to forests that are being managed under sustainable standards associated with certified forest programs such as American Tree Farm (ATF), Sustainable Forestry Initiative (SFI), Forest Stewardship Council (FSC) or other equivalent certified forest management programs.
- Restriction of biomass harvests to forests that are being managed under Forest Stewardship Plans as approved by the Kentucky Division of Forestry.
- Development of size limits for woody biomass material that allows for the appropriate retention of leaves, current year's growth, and branches.
- Restriction of biomass harvests to material not potentially useable for other forest products or material that would not reduce the potential for the production of high valued sawtimber and veneer trees.
- Requirements for the use of approved woody biomass harvesting practices that would include stipulations for harvesting equipment and practices that retain appropriate levels of woody material for nutrient retention, maintain habitats and soil productivity, ensure proper regeneration of diverse native species, and reduce the invasion potential of exotic species.

Most certified forest standards (with the possible exception of FSC) and traditional management

**Average annual gross growth, removals, mortality, and net change of growing-stock trees on timberland**



planning were not developed in a manner that considers a strong woody biomass market and large-scale biomass harvesting.

However, general woody biomass harvesting guidelines have been developed and regional guidelines are in the development process. Furthermore guidelines could be specifically developed for the Commonwealth. This strategy would allow flexibility in marking harvests to satisfy landowner interests, provide for sustainable forest management and address some of the important ecological concerns associated with biomass harvests. While the scenario presented above helps to develop harvests and biomass extractions that are appropriate at the stand or woodlands level it is not sufficient to avoid overharvesting at the state level. Continuous monitoring of forest resources becomes extremely important and Kentucky should develop methods to respond to data that indicate levels of harvests that are not sustainable.

To ensure that woody biomass can be effectively and sustainably produced in Kentucky the following should be considered:

- Determination of accurate estimates of woody biomass availability
- Development of woody biomass plantation production and harvesting techniques
- Determination of appropriate harvesting technologies and costs for managed forests
- Incentives to increase forest management planning and certification
- Determination of guidelines for ecological harvesting of woody biomass
- Incentives to improve logging capacity to harvest biomass
- Increased capacity to monitor forests and provide technical assistance for forest management planning (budget considerations and capacity building within the Kentucky Division of Forestry)
- Increase biomass information delivery to logging and other forest industries (through the Kentucky Master Logger program)
- Development of educational programs for woodland owners on forest management, certification, and biomass markets and harvesting (through Cooperative Extension Service)

The Kentucky Division of Forestry, the land grant agricultural colleges and Extension Services at Kentucky State University and the University of Kentucky, the University of Kentucky Department for Forestry and partnership ventures among the Kentucky Forest Industries Association can be supported to provide much of the afore mentioned considerations. (Stringer, 2009)

### ***1.3.2 Agriculture***

The current food versus fuel debate centers primarily around the lack of a definition for “sustainable agriculture,” Sustainable agriculture is a controversial term whose definition depends more upon opinion than science. With the contradictions and questions, the United States is taking a hard look at its present food production system to assess its sustainability. If nothing else, the term “sustainable agriculture” has provided a sense of direction, and an urgency that has sparked much excitement and innovative thinking in the agricultural world.

The word “sustain,” from the Latin *sustinere* (*sus-*, from below and *tenere*, to hold), to keep in existence or maintain, implies long-term support or permanence. As it pertains to agriculture, sustainable describes farming systems that are

“capable of maintaining their productivity and usefulness to society indefinitely. Such systems... must be resource-conserving, socially supportive, commercially competitive, and environmentally sound.” [John Ikerd, as quoted by Richard Duesterhaus in "Sustainability's Promise," *Journal of Soil and Water Conservation* (Jan.-Feb. 1990) 45(1): p.4. NAL Call # 56.8 J822]

Sustainable agriculture was addressed by Congress in the 1990 Farm Bill. Under that law, “the term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will, over the long term:


- satisfy human food and fiber needs
- enhance environmental quality and the natural resource base upon which the agricultural economy depends
- make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
- sustain the economic viability of farm operations
- enhance the quality of life for farmers and society as a whole.” (USDA, 2007)

Kentucky must open discussions surrounding sustainable agriculture and develop its own definition, especially as agricultural production is targeted for energy generation.

## 1.4 Environmental and Conservation Standards

Since land-use changes have a significant impact on greenhouse gas emissions, it is important to know whether increased biofuels production will be met through improved land productivity or through expansion of cultivated area. Intensive research has produced significant improvements in crop yields, but has focused primarily on food crops rather than energy crops. Some potential biofuel crops such as miscanthus and sweet sorghum, may be able grow on marginal land where food crops cannot flourish. However, growing any crop, including those that are drought resistant, on land with low levels of water and nutrient inputs will result in lower yields. It is therefore likely that

bioenergy will intensify the pressure on the fertile lands where higher returns can be realized.



### Principles for Sustainable Bioenergy

- Reduce greenhouse gas emissions
- Prevent conversion of native ecosystems
- Protect biodiversity
- No invasive feedstocks
- Maintain water quality and quantity
- Minimize chemical inputs
- Protect soil health
- Biotechnology must improve performance
- Do not impair food security
- Respect land tenure and labor rights

During bioenergy production, water is used in large quantities for washing plants and seeds and for evaporative cooling. The availability of water resources may constrain the production of biofuel crops in areas that do not have sufficient water supplies. If irrigation water is needed in times of lower rainfall, the stress on water resources can be significant.

Producing more energy crops will also affect water quality. For example, converting pastures or woodlands into energy crop fields may increase problems of soil erosion and runoff of excess nitrogen and phosphorous into surface and groundwater. Pesticides and other chemicals can also wash into lakes and streams. Of the principal

feedstocks, corn is the one requiring the greatest amount of fertilizer and pesticides per acre.

Changes in land-use and intensification of agricultural production also have the potential to harm soil condition, but these impacts depend on the way the land is farmed. Various farming techniques can reduce adverse impacts or even improve environmental quality while still increasing biofuel crop production. These include conservation tillage and appropriate crop rotations.

Removing plant residues that would otherwise nourish the soil and permanent soil cover that prevents erosion can reduce the quality of soil. Only 25 to 33% of available crop residues from grasses or corn can be harvested without detrimental effects on soil quality, especially on soil organic content. The use of perennial plants that can be harvested over several years such as miscanthus or switchgrass can also improve soil quality by increasing soil cover and organic carbon levels compared with annual crops like canola, corn or other cereals. Crops such as eucalyptus, poplar, willow or grasses can be grown on poor-quality land, and soil carbon and quality will tend to improve over time.

Energy crop production can affect wildlife and agricultural biodiversity in some positive ways, for instance through the restoration of degraded lands, but many of its impacts will be negative, for example when natural landscapes are converted into energy-crop plantations. Conversion of forest or grassland for crop production has a significant effect on wildlife biodiversity, because of the loss of habitat. For existing arable land, positive impacts on farmland biodiversity can be obtained by using crops which increase soil cover, avoiding tillage and reducing fertilizer and pesticide inputs.

The genetic diversity of crops can be compromised where large-scale production is practiced. Most biofuel feedstock plantations are based on a single species, using a narrow pool of genetic material, with traditional varieties being used less and less. Such low levels of genetic diversity increase the susceptibility of crops to new pests and diseases.

Second-generation feedstocks raise their own concerns, since some of the proposed plant species can be invasive. Similarly, care will be required when dealing with genetically modified bacteria that produce enzymes used for cellulose conversion.

Crops which do well on fertile soils may not be as effective in poorer conditions. For example, switchgrass performs less well on poor soils than a diverse mixture of native grassland perennial plants. In addition, such diverse mixtures can provide better wildlife habitat, water filtration and carbon sequestration than corn or soybeans alone.

The adoption of “good practices” in soil, water and crop protection, energy and water management, nutrient and chemical management, biodiversity and landscape conservation, harvesting, processing and distribution can contribute significantly to making bioenergy sustainable. For instance, good agricultural practices, such as conservation agriculture, and good forestry practices, can reduce the adverse environmental impacts of biofuel production.

The environmental concerns about biofuel feedstock production are the same as for agricultural production in general, and existing techniques to assess the environmental impact offer a good starting point for analyzing the biofuel systems. The development of sustainability criteria or standards is already under way in a number of States and at the national level, and should be established in Kentucky with the active collaboration of stakeholders. (United Nations Food and Agriculture Organization, 2008)

## ***1.5 Findings and Conclusions***

1. Current biomass production capabilities are estimated at 12-15 million tons per year with minimal land use changes. Approximately 30% of this volume is expected from forestry and woody biomass production, 30% from energy crop production, 20% from waste forest products and 20% from agricultural waste.

2. Potential Biomass production capabilities by 2025 are estimated at 25 million tons per year, but could involve land use changes of approximately 2 million acres, or 15% of Kentucky's farmland. Approximately 20% of this volume is expected from forestry and woody biomass production, 60% from energy crop production, 10% from waste forest products and 10% from agricultural waste.
3. To minimize land use changes, advances in biotechnology must occur that improve biomass adaptability so that marginal and reclaimed lands become productive, and that increase current biomass yields on all lands.
4. Kentucky currently has no standards for biomass sustainability, resulting in diverse opinions of sustainability definitions. Actions on sustainability standards at the federal level may pre-empt Kentucky's interests, however, the Commonwealth should develop its own standards and become active in the federal process.
5. The Task Force concludes that 25 million tons of biomass per year, produced within a sustainable environment defined by the Commonwealth with land use changes involving 15% of Kentucky's farmland, is feasible by 2025 if improvements in yield and adaptability are realized.

## Biomass Demand by 2025

***“Validate Kentucky’s potential biomass demand.”***

### 2.1 Carbon Management Overview

Kentucky’s high carbon footprint is largely due to the fact that 95% of its electricity is produced from coal (EIA). Kentucky, along with other states will feel pressure to minimize its carbon footprint. The United States House of Representatives has passed a bill that will impose carbon constraints on greenhouse gas emitters throughout the country. Kentucky has limited opportunity to reduce its carbon emissions without the development of biomass. Other sources of renewable electricity such as wind, solar and hydro can help Kentucky reduce its emissions but these sources provide challenges. Solar and wind systems provide electricity intermittently as solar radiation and optimal wind speeds are not always available. Therefore they cannot contribute to base load generation. Kentucky can and will develop more generation from hydroelectric plants but not at a capacity that reduces our carbon liability completely.

Kentucky does have a large amount of land (total of 25.4 million acres) with 13.5 million acres classified as farmland. Of that, only 5.0 million acres are harvested with the other 8.5 million acres of farmland in pasture, rangeland, or woodlands. In addition, 11.9 million acres of forest land is available with most of the land in private ownership. Kentucky has a relatively long growing season with significant rainfall that could produce sizeable quantities of perennial herbaceous and woody biomass on land that does not compete with food crops if there were appropriate incentives in place. Kentucky therefore does have the potential to meet a portion of its generation demand with biomass, a carbon-neutral fuel.

Public opinion and legislation will likely continue to place an emphasis on reducing carbon emissions. In addition, reports from organizations such as the Brookings Institute that rate Lexington and Louisville as the nation’s largest carbon emitters will also continue to pressure Kentucky.

There is significant interest in providing electric power from renewable resources as evident by the request for proposals from EKPC (2008) and the co-firing of switchgrass in Maysville during December 2008. Co-firing of switchgrass, miscanthus, and wood have been done before at numerous locations. One example is the Chariton Valley Project in Iowa where 3% of the heat input to a 725 MW pulverized coal plant was supplied by switchgrass. However, the plant is no longer operational because farmers have decided to produce corn and soybeans instead of switchgrass due to economics. Fifteen power plants are annually co-firing 3.3 million tons of miscanthus briquettes in the United Kingdom. The global wood pellet market is estimated at 10 million tons, the majority being utilized in Europe for power generation. Wood pellets imported from the US into Europe have recently been between \$150 and \$200/ton. Fortunately, Kentucky has a large amount of land unsuitable for traditional row crop agriculture that could be used for energy production whether it is switchgrass, miscanthus, wood or other feedstocks that can reduce Kentucky’s carbon footprint. (DEDI, 2008)

### 2.2 Federal Renewable Fuels Standard

On December 19, 2007, the Energy Independence and Security Act of 2007 (H.R. 6) was signed into law. This comprehensive energy legislation amended the Renewable Fuels Standard (RFS) signed into law in 2005, growing to 36 billion gallons in 2022. By doing so, the bill seizes on the potential that renewable fuels offer to reduce foreign oil dependence and greenhouse gas emissions and provide meaningful economic opportunity across this country, putting America firmly on a path toward greater energy stability and sustainability.

As a result of the 2007 RFS mandate, Kentucky consumers now use 10 percent biofuels in over 70 percent of their gasoline. However, only 24 percent of the biofuels currently consumed is produced instate with the balance being imported primarily from the Midwest. As the mandate expands over the next 13 years, the average biofuels blend rate will increase to over 25 percent further increasing our need for biofuels imports. This will increase Kentucky's demand for biofuels from 150 million gallons to 775 million gallons per year. If Kentucky fails to expand its biofuels production, the Commonwealth will import nearly 90 percent of its renewable fuels in 2022, the final year of RFS expansion.

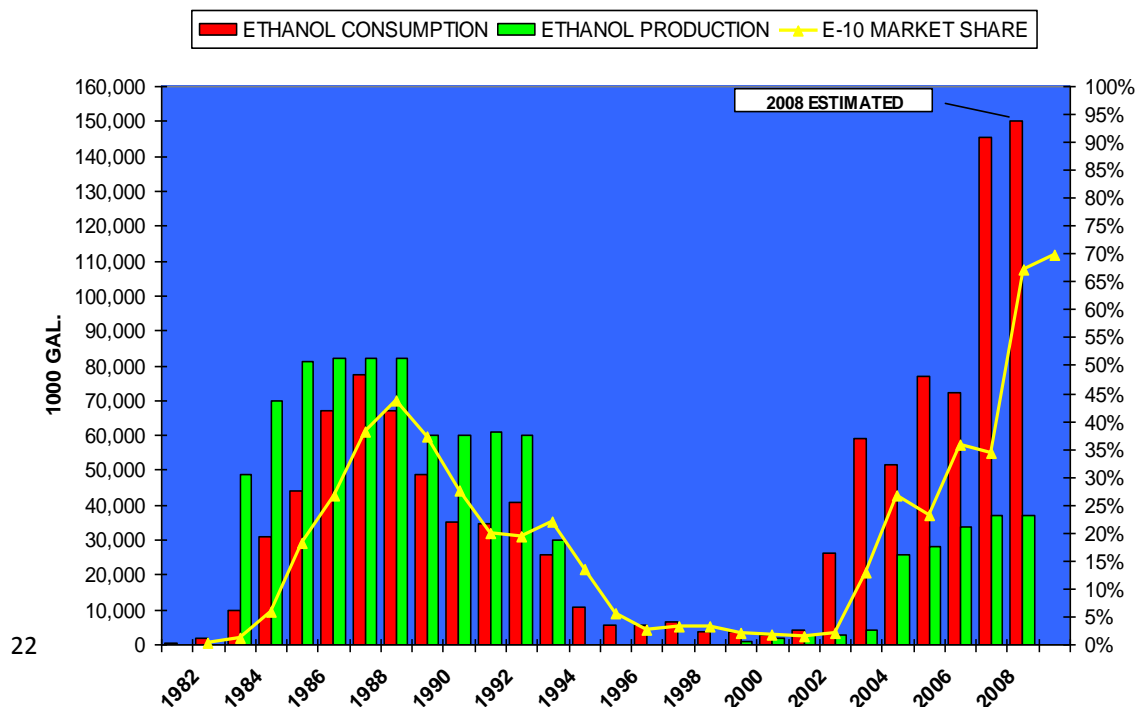
The RFS establishes definitions for the renewable fuels program, including conventional biofuel, advanced biofuels, cellulosic biofuels and biomass-based diesel:

**Conventional biofuel** is ethanol derived from corn starch. Conventional ethanol facilities that commence construction after the date of enactment must achieve a 20 percent greenhouse gas (GHG) emissions reduction compared to baseline lifecycle GHG emissions. The 20 percent GHG emissions reduction requirement may be adjusted to a lower percentage (but not less than 10 percent) by the U.S. Environmental Protection Agency (EPA) Administrator if it is determined the requirement is not feasible for conventional biofuels.

**Advanced biofuels** is renewable fuel other than ethanol derived from corn starch that is derived from renewable biomass, and achieves a 50 percent GHG emissions reduction requirement. The definition – and the schedule -- of advanced biofuels include cellulosic biofuels and biomass-based diesel. The 50 percent GHG emissions reduction requirement may be adjusted to a lower percentage (but not less than 40 percent) by the Administrator if it is determined the requirement is not feasible for advanced biofuels. (Cellulosic biofuels that do not meet the 60 percent threshold, but do meet the 50 percent threshold, may qualify as an advanced biofuel.)

**Cellulosic biofuels** is renewable fuel derived from any cellulose, hemicellulose, or lignin that is derived from renewable biomass, and achieves a 60 percent GHG emission reduction requirement. The 60 percent GHG emissions reduction requirement may be adjusted to a lower percentage (but not less than 50 percent) by the Administrator if it is determined the requirement is not feasible for cellulosic biofuels. (Renewable Fuel Association, 2008)

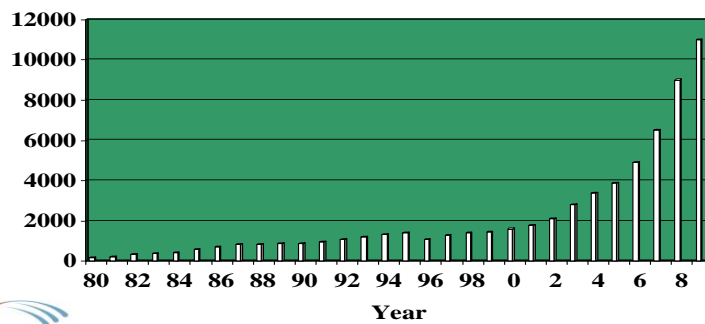
## ETHANOL HISTORY IN KENTUCKY



The phase-in for renewable fuel volumes is outlined as follows:

Year	Conventional Biofuel	Advanced Biofuel	Cellulosic Biofuel	Biodiesel & Other Advanced Biofuel	Total RFS
2008	9.0				9.0
2009	10.5	.6		0.6	11.1
2010	12	.95	.1	0.85	12.95
2011	12.6	1.35	.25	1.1	13.95
2012	13.2	2	.5	1.5	15.2
2013	13.8	2.75	1	1.75	16.55
2014	14.4	3.75	1.75	2	18.15
2015	15	5.5	3	2.5	20.5
2016	15	7.25	4.25	3.0	22.25
2017	15	9	5.5	3.5	24
2018	15	11	7	4.0	26
2019	15	13	8.5	4.5	28
2020	15	15	10.5	4.5	30
2021	15	18	13.5	4.5	33
2022	15	21	16	5	36

## U.S. Fuel Ethanol Production (million gallons)



## *2.3 Renewable Portfolio Standard*

A Renewable Portfolio Standard (RPS) is a regulation that requires the increased production of energy from renewable energy sources, such as wind, solar, biomass, and geothermal. Another common name for the same concept is renewable electricity standard (RES). When coupled with conservation and efficiency requirements, the standard is referred to as a REPS, Renewable and Efficiency Portfolio Standard. The United States House of Representatives has passed a REPS and the Senate has proposed one.

The RPS mechanism generally places an obligation on electricity supply companies to produce a specified fraction of their electricity from renewable energy sources. Certified renewable energy generators earn certificates for every unit of electricity they produce and can sell these along with their electricity to supply companies. Supply companies then pass the certificates to some form of regulatory body to demonstrate their compliance with their regulatory obligations. Because it is a market mandate, the RPS relies almost entirely on the private market for its implementation. Those supporting the adoption of RPS mechanisms claim that market implementation will result in competition, efficiency and innovation that will deliver renewable energy at the lowest possible cost, allowing renewable energy to compete with cheaper fossil fuel energy sources.

An RPS is a useful tool for mitigating the economic impact of greenhouse gas reductions. In the American Clean Energy and Security (ACES) Act passed by the U.S. House of Representatives, carbon along with other greenhouse gases are capped beginning in 2012. To achieve the cap, ACES establishes tradable permits called emission allowances. Major sources will need to obtain allowances for each ton of carbon or its equivalent emitted into the atmosphere. There are several cost-containing measures in the bill, but it will increase the cost of using carbon-intensive fuels. Since renewable fuels do not emit carbon or are considered carbon neutral, they can offset carbon intensive fuels and reduce the quantity of allowances that must be obtained. Therefore, meeting an RPS will reduce the cost of carbon constraints.

However, meeting an RPS can increase the cost of electricity. This added cost, if passed on to the consumer, will increase electricity rates. Positive economic impacts from developing a bioenergy industry will offset that added cost. However if Kentucky fails to make the investment needed to develop a bioenergy industry the state will have to purchase its renewable electricity and credits from other states thereby enduring rising electricity rates without receiving the benefits of building its own industry.

RPS-type mechanisms have been adopted in Britain, Italy and Belgium, as well as in 32 U.S. states, Chili and the District of Columbia. Five of the 32 states have voluntary rather than mandatory goals. Regulations vary from state to state, and there is no federal policy at the current time. Thirty of these states account for almost 50 percent of the electricity sales in the United States.

RPS mechanisms have tended to be most successful in stimulating new renewable energy capacity in the United States where they have been used in combination with federal Production Tax Credits (PTC). In periods where tax credits have been withdrawn, the RPS alone has often proven to be insufficient stimulus to incentivize large volumes of capacity.

Of all the state-based RPS programs in place today, no two are the same. Each has been designed taking into account state-specific policy objectives (e.g. economic growth, diversity of energy supply, environmental concerns), local resource endowment, and the capacity to expand renewable energy production. Other factors in program design include resource eligibility, in-state requirements, new build requirements, technology favoritism, cost caps, program coverage (IOUs versus Cooperatives and Municipal utilities), cost recovery by utilities, penalties for non-compliance, rules regarding Renewable Energy Credit creation and trading, and additional non-binding goals.

In Kentucky, it is expected that a Federal RPS mandate would be met primarily through biomass co-firing and importing renewable electricity and buying renewable electricity credits from upper Midwestern states. To achieve the RPS, Kentucky will be forced to compete against other states for limited renewable electricity resources, which will have a profound negative impact on our electric rates.

## ***2.4 Findings and Conclusions***

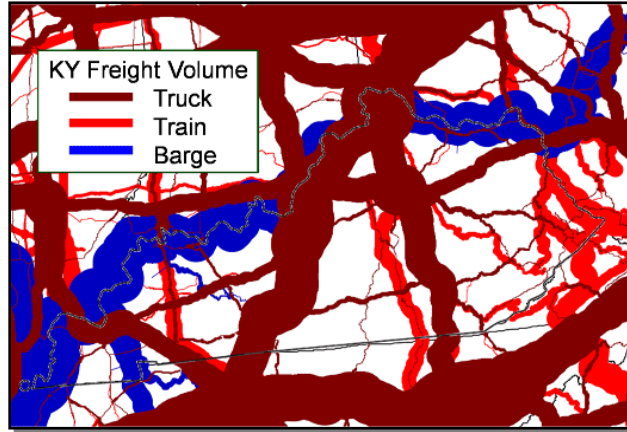
1. As carbon dioxide becomes a regulated greenhouse gas, Kentucky's cost of electricity is at high risk unless supplemented by renewable energy.
2. Kentucky' geography and climate give it an advantage for meeting a portion of base load generation with biomass.
3. By 2025 Kentucky can produce 2000 megawatts of renewable electricity capacity using 15 million tons of biomass. This is a feasible means of reducing electricity cost risks associated with carbon management.
4. Adoption of a Renewable Portfolio Standard at the federal and/or state level is necessary to mitigate increased electricity rates due to carbon management and to spur in-state demand for biomass while capturing related job creation in-state. The adoption of a federal standard alone may not be enough to develop in-state demand for biomass for production of electricity; therefore policies at the state level may also be needed to complement a federal standard.
5. Demand in Kentucky for 10 million tons of biomass by 2022 for the production of 700 million gallons of liquid transportation fuels is being driven by mandates created by the Federal Renewable Fuels Standard.
6. The Task Force concludes that the potential demand in Kentucky for biomass is 25 million tons of biomass per year by 2025.

## BIOMASS TRANSPORTATION AND LOGISTICS

*“Evaluate biomass transportation and logistics opportunities, and recommend a course of action.”*

### 3.1 Current Transportation Infrastructure

Kentucky is well served by water, rail, and road freight corridors. The Ohio River, which runs along its northern border, is second only to the Mississippi in annual freight volume carried on a US waterway. The Ohio River and its tributaries carry more than 270 million tons of freight annually. Most of Kentucky's coal-fired power plants are located on the Ohio River, making barges an attractive option for transporting biomass intended for co-firing in existing plants. Barges are the least expensive and most energy efficient means of transporting biomass, costing 1-2 cents and consuming about 900 BTU per ton-mile.



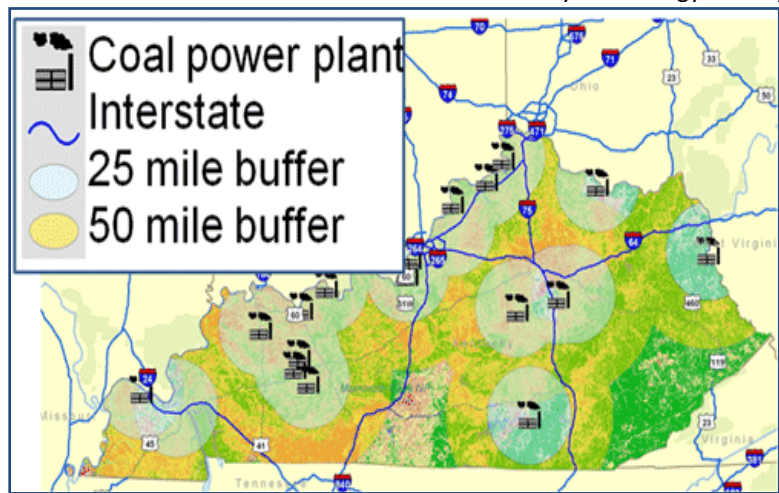
Major rail corridors run north-south along Kentucky's eastern border, through central Kentucky (Corbin-Lexington-Cincinnati), and through western Kentucky (Hopkinsville-Madisonville-Henderson). At 2-6 cents per dry ton-mile, moving freight by train is usually more expensive than by barge. Trains consume 900-2000 BTU per dry ton-mile.

Most of Kentucky's truck freight moves along the interstates, with heavy volumes on I-65, I-71, and I-75. At 20-60 cents and 3400 BTU per dry ton-mile, trucking is the most expensive and least energy efficient freight hauling option, yet trucking is usually the only way to move biomass from farms or forests, which are more often serviced by roads than railroads or waterways. Trucking can save money and energy by offering the most direct route to a destination. As a rule of thumb, biomass should not be trucked more than 50 miles in order to allow a reasonable return on investment of energy and money.

### 3.2 Logistics Opportunities

Logistical considerations include the need to create efficient feedstock harvest, storage, pre-processing, and transport systems. Logistics will differ by feedstock and end user. Biomass tends to have a lower bulk density and energy density than fossil fuels. Fifteen to twenty trucks of chopped switchgrass or logging residue are needed to deliver as much feedstock energy to a power plant as a single truckload of coal. Baling, chipping, or pelleting biomass increases its density two to eight-fold, but even in its most concentrated forms, biomass has half the energy density of the fossil fuels that currently supply most of our energy.

Coal-fired power plants are the ultimate destination of biomass intended for co-firing. Coal-fired plants require dry material (<15% moisture) that can be blended with

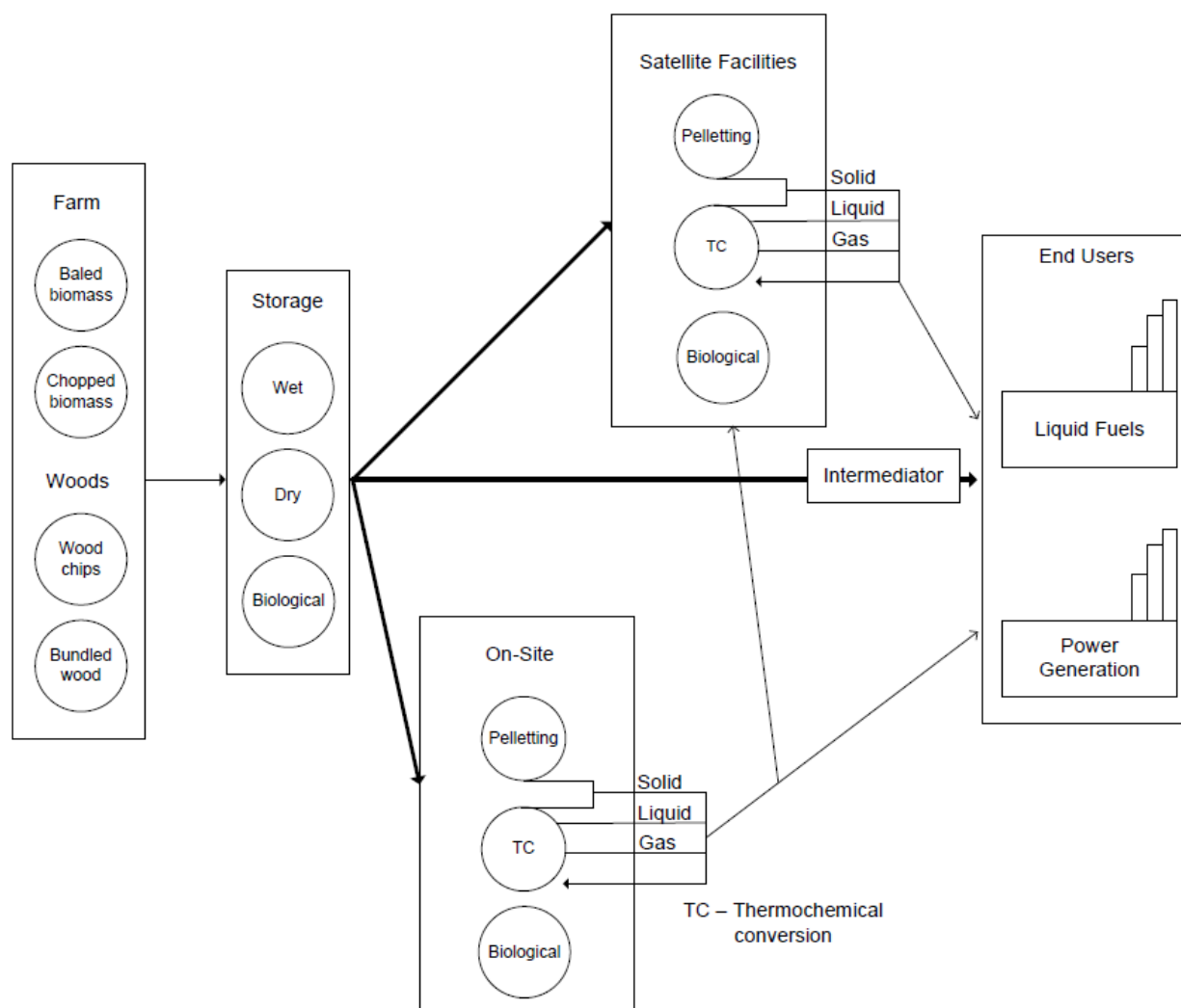


coal and fed into a hammer mill. Eighty-six percent of Kentucky's agricultural land and 80% of its forest lies within 50 miles of a coal-fired electricity plant. A predominantly agricultural section of south central Kentucky and a largely forested section of south-eastern Kentucky represent the only large areas that are more than 50 miles from a power plant. Thirteen of Kentucky's 17 coal-fired power plants are accessible by barge; most others are accessible by rail. Kentucky's geography and transportation infrastructure offers opportunities to couple highly efficient barge and rail transport with short-haul trucking to move biomass from fields and forests to power plants. Utilizing geographically diverse power plants to co-fire with biomass reduces the need to transport biomass long distances. Any new power plants, including biomass only power plants, should be sited near rail or barge corridors, with preference given to areas rich in harvestable biomass that are not already near existing power plants.

Kentucky has two commercial scale ethanol plants, and two biodiesel plants, with a third under construction. About 14 new plants with a capacity of 50 million gallons per year are needed to produce the 775 million gallons of liquid transportation fuel called for by the governor's energy plan. New construction offers opportunities to site and size plants appropriately to optimize sustainability of Kentucky's domestic biofuel supply chain.

**Bulk density and energy density of a range of biological and fossil-based feedstock formats.**

Format	Shape and Size	Bulk Density (lb/ft <sup>3</sup> )	Energy Density (Thousand Btu/ft <sup>3</sup> )
<b>Chopped switchgrass</b>	¾"-1½" loose fill	3.7-5	30-40
<b>Logging residue</b>		5-7	40-60
<b>Round baled switchgrass</b>	Full length	7.5-8.7	60-70
<b>Square baled switchgrass</b>	Full length	8.7-11	70-87
<b>Dry wood chips</b>	2"x2"x3"	12-28	96-224
<b>Pulpwood</b>	Logs up to 75'	20-40	120-300
<b>Switchgrass briquettes / pellets</b>	1.3" diam. x 1"	22-44	175-350
<b>Coal</b>		50-60	550-660
<b>Pyrolysis oil</b>		75	750
<b>Crude oil</b>		55	990



**Biomass will be dried, densified, chemically converted and stored at various points along the feedstock supply chain connecting farms and forests to end users.**

Distribution of 15 million tons of woody biomass to 10-20 electrical plants and 10 million tons of grain and herbaceous biomass to 10-20 liquid fuel processors will be complicated by the huge volume of material to be moved. Drying and densification of material early in the supply chain will prepare biomass for processing and reduce freight costs by reducing weight and volume.

The relative importance of feedstock logistics varies with feedstock. Transportation of grain-based feedstocks for first generation biofuel production accounts for less than 3% of the lifecycle energy investment: Most of the energy investment goes to crop production and biofuel processing. The transition to cellulosic feedstocks will increase the relative importance of logistics because the amount of energy needed for crop production and processing will decline while the bulk and energy density of the feedstock increases.

Optimizing energy return from cellulosic biomass will require efficient production and transportation of biomass. Tactics that will promote efficiency include:

- low input feedstock production;
- biomass drying and concentration before hauling;
- minimized hauling distance;
- maximized load size;
- use of barge and rail transport, where possible; and
- maximized use of renewable fuels throughout the supply chain.

A decentralized system with up to 100 collection and densification terminals is envisioned to add value to biomass and prepare it for sale to power plants and liquid fuel plants. Cooperative ownership of these satellite terminals can save individuals the investment needed to efficiently condense biomass early in the supply chain.

### *3.2.1 On-site Processing*

Individual landowners will be responsible for biomass harvest and sale to satellite terminals or end users. Landowners may choose to add value to their biomass through pre-processing such as drying, baling, bundling, and chipping. Custom operators may invest in specialized machinery that can be used for on-site processing at several farms. Appropriate harvest and on-site processing tactics will differ by feedstock:

- Corn stover, wheat straw, and other crop residues can be harvested with grain to reduce field passes, but additional drying will likely be needed after harvest. Alternatively, an initial pass could harvest the grain and a second pass could harvest the straw and stover after field drying. Straw and stover will be baled before transport to satellite terminals.
- Switchgrass, other grasses, and perennial mixtures can be dried in the field before baling. Harvest will likely occur between August and March. Round bales can be stored in the field for some time because of their ability to shed water. Large square bales are easier to haul, but should be stored under cover. Chopping and pelleting will probably occur at satellite terminals.
- Sweet sorghum is a low-input energy crop that grows well in Kentucky. It must be cut wet for juicing, so a forage harvester system will be needed. The harvest window runs from maturity in late August until the first hard frost in late October. On-farm processing will likely include juice extraction, and may even involve fermentation to reduce perishability.
- Sunflower and canola have a short fall and spring harvest windows, determined by seed moisture content. On-farm processing will involve threshing to produce clean seed for sale. Oil extraction will probably occur at satellite terminals or biodiesel plants.
- Woody biomass can be chipped at harvest, or bundled and trucked to a satellite site for chipping.



### *3.2.2 Collection and Densification*

Densification requires some specialized equipment that will be prohibitively expensive to many landowners. Up to one hundred collection and densification terminals can be distributed throughout the state to prepare material for hauling. A typical terminal will:

- 1) be able to accept thirty 25-ton truckloads of biomass daily;
- 2) have sufficient space to dry and store the biomass if necessary (~60 acres);
- 3) have chipping and pelletizing equipment to densify biomass; and
- 4) be located near rail or water corridors to facilitate lower-cost hauling to the power plant or liquid fuel processor.



Satellite terminal will handle most small contracts with individual landowners and pool materials so as to arrange larger contracts with power plants and liquid fuel processors. Satellite terminals may be cooperatively owned and managed by feedstock producers.

Some advanced satellite terminals may invest in equipment to produce pyrolysis oil or syngas. These technologically advanced conversions can produce energy-dense and easily-transported liquid and gaseous materials, along with heat and electricity.

### *3.3 Findings and Conclusions*

1. Transportation and logistics for 25 million tons of biomass will likely be centered upon a combination of up to 100 collection and densification facilities along with some on-site processing.
2. While some biomass will move directly from producers to processors by truck, the large volumes will require access to both rail and barge.
3. Supply chain ownership is a critical consideration in the development of a biomass transportation and logistics system.
4. Of the 10,000 permanent jobs that a 25 million ton per year biomass industry is expected to generate, most are expected to be transportation and logistics related.

## BIOMASS TECHNOLOGY

***“Evaluate the status of energy crop and forestry biotechnology and genetics, and recommend a plan of action that allows biotechnology to support biomass production.”***

### ***4.1 Current Status of Production Biotechnology***

Kentucky agriculture has a rich history of providing leadership and innovation in the production of agronomic crops. The Commonwealth's farmers continue to produce more on fewer acres through more sustainable production methods. The development, implementation, and utilization of advancements in the area of biotechnology related to biomass production show tremendous promise. Earlier sections of this report discuss the existing and potential supply of these biomass resources. Scientific progress will be essential in meeting these projections and capturing these opportunities. This area will report on the strong biotechnological foundation currently found in Kentucky, identify immediate opportunities for collaboration and investment, list potential concerns related to this subject, and chart a course of action for success.

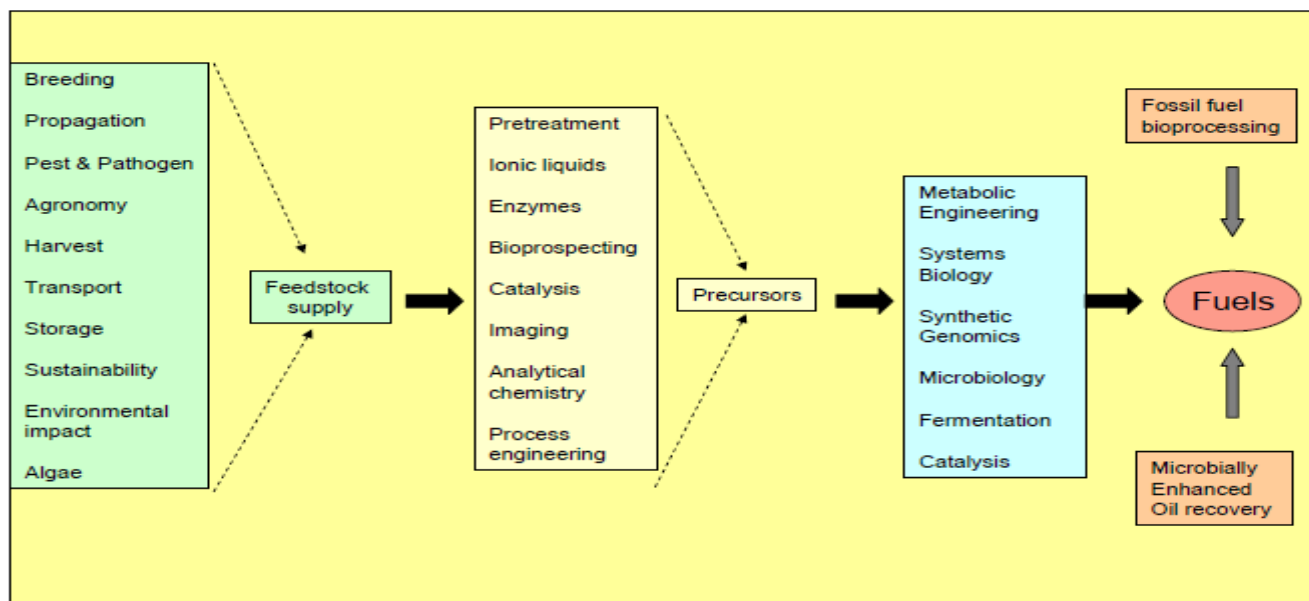
#### ***4.1.1 Energy Crops***

The current standard energy crops in the U.S. are corn for ethanol production and soybeans for biodiesel production. Corn is the dominant feedstock for ethanol production due to its high yield (2.8 gallons ethanol/bu), storability, ease of processing into ethanol, and its net positive energy balance. However, numerous media reports have blamed ethanol and biodiesel production on increased food prices and a host of other issues. As a result, federal mandates such as the Renewable Fuels Standard (RFS) will likely result in a large demand for biomass to make second generation fuels to replace starch based ethanol and vegetable oil based biodiesel.

Data from the KY Department for Energy Development and Independence indicated that 10% ethanol is in over 70% of the gasoline marketed in Kentucky. The RFS requires 9 billion gallons of ethanol and biodiesel to be utilized in 2008 and to increase to 36 billion gallons by 2022. Most of the increased biofuel consumption has to be from non-starch sources. Assuming an ethanol yield of 80 gallons/ton of biomass, approximately 10 million tons of biomass would be required to produce the 700 million gallons of ethanol that Kentucky would require in 2022.

Additionally, if a Renewable Portfolio Standard (RPS) for electricity is implemented, considerable demand for renewable electricity will exist. Combustion of biomass would appear to be a feasible alternative to generate renewable electricity. Kentucky consumed 41.9 million tons of coal in 2006 for electric power generation. If 20% of the heating value was generated with biomass, 12 million tons of biomass would be required. Producing alternative crops for energy production that directly competes with corn and soybeans would probably be difficult due to economic constraints, especially in Western and Central Kentucky. The total biomass required for renewable energy in Kentucky could likely be in excess of 25 million tons by 2022. Maximizing biomass yield and minimizing environmental impacts will be a significant hurdle to meet the potential demand. The example numbers are based on Kentucky, but numerous other areas across the US will face similar problems.

Utilizing biomass for renewable energy production will require a number of steps before it is implemented on a large scale across Kentucky. Permitting and plant/refinery design changes, crop selection, harvest, storage, and logistics are a few of the major hurdles to be overcome before biomass is an economically viable alternative. Considerable work has been conducted on individual components, but few examples of an integrated comparison of potential energy crops have been performed. The quantity of biomass produced as a function of crop type, land type, and climatic conditions are not well documented. Additionally, potential changes to the carbon and nitrogen cycling between the soil, air, and energy crop need to be documented.



## 4.1.2 Forestry

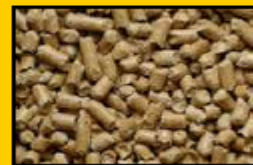
The Task Force discussed two opportunities to use woody biomass to produce electricity. First diseased trees or trees which are not desirable for lumber, are processed into wood pellets or Renewable Densified Fuel (RDF) and co-fired with coal to produce electricity. The amount of low-quality timber that is often left in the forest after loggers harvest the more desirable timber can be gathered and ground for transformation into wood pellets. According to Turner Martin of Turner & Conyer Lumber Company in Marion, KY, a 40 lb. bag of these pellets can replace 2.4 gallons of oil and burns at approximately 8,000 BTU. Stom debris can also be utilized in this way. The Land Between the Lakes is setting up a program to use debris from the 2009 ice storm to generate electricity.

The second process that was discussed was the creation of new varieties of trees that are more efficient in producing biomass. This process is in the beginning stages of examination and research in Kentucky. There is a revolutionary new fast-growing hardwood tree called the Empress Splendor that can be planted in land that is undesirable for crops and can be harvested every 7 years. According to Martin, this species must be planted in dry soil and regenerates directly off the stump. It can produce 30,000 board feet per acre over a 50 year period, and during this 50 year period, 50 acres of growth produces 18 thousand tons of fuel biomass.

## Potential Biomass Sources

Initial estimates—9.18 million dry tons/year

- Wood and bark from current harvests (1.95)
- Woody debris from urban sources (0.34)
- Material from thinnings and other forest improvement treatments (1.21)
- Biomass energy plantings--biomass plantations (3.78)
- Annual net growth currently unused (1.90)



### 4.2 Current Status of Conversion Technology

Biomass conversion technology is broken down into two distinct areas: Thermo chemical and biochemical. The main difference between the two processes is the amount of oxygen and the type of product, be it gas or liquid, which is produced as a result. The technology for the conversion of biomass to biofuels is currently proceeding through the demonstration phase and entering commercialization. Florida and Georgia have invested in the Southeast's first two commercial cellulosic ethanol projects, and Tennessee is invested heavily in similar demonstration activities.



Ethanol Plant

### 4.2.1 Biochemical Conversion

Biochemical conversion refers to the process of breaking down, or hydrolyzing, the carbohydrates in organic matter, which can then be metabolized by bacteria or yeast into gaseous or liquid metabolic products. These gaseous or liquid products can then be separated, concentrated, and utilized for fuel.

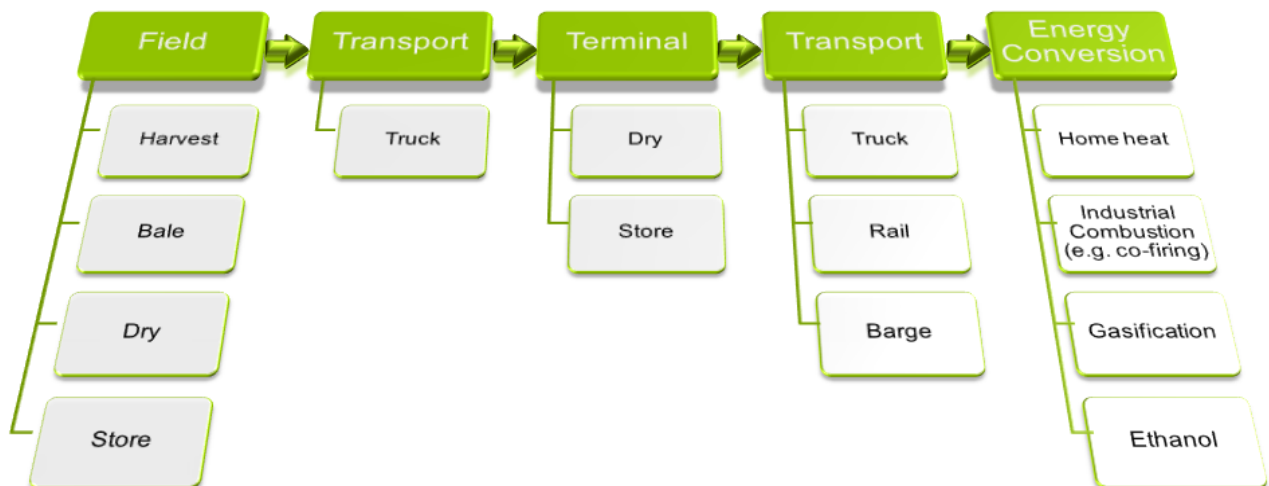
#### 4.2.1.1 Biomass

Biomass refers to any plant-derived organic matter. Biomass available for energy on a sustainable basis includes herbaceous and woody energy crops, agricultural food and feed crops, agricultural crop wastes and residues, wood wastes and residues or aquatic plants. It also encompasses manure and other waste materials, including some municipal wastes, such as that found in landfills.

Biochemical conversion of biomass for ethanol production from ligno-cellulosic feedstocks involves:

- Pretreatment of the feedstock using high-temperature, high-pressure acid; enzymes; or other methods to break down the lignin and hemi-cellulose that surround the cellulose.
- Hydrolysis using enzymes and acids to break down the cellulose into sugars.
- Fermentation to convert the sugars into ethanol (as in corn-based ethanol production).
- Distillation to produce fuel ethanol (as in corn-based ethanol production).

Developing advanced biofuel technologies may also use biochemical conversion of synthesis gases from traditional gasification processes.



Herbaceous Biomass to Energy

#### 4.2.1.2 Animal Manure Biogas

Anaerobic digestion of manure is another method of biochemical conversion of biomass, and in this case, waste biomass. Methane, a natural product of organic degradation, is approximately 21 times more destructive to the environment than carbon dioxide emissions. Animal waste contributes to approximately 8% of methane/CO<sub>2</sub>

emissions annually. Capturing and utilizing methane from livestock operations through the process of anaerobic digestion is an important component of a viable renewable energy strategy. Through anaerobic digestion, organic materials are placed in an oxygen-free holding tank containing bacteria which break down the organics into methane. The methane is then recovered for private and public consumption in the form of steam, electricity, etc.

Manure from large scale dairy operations (500 or more head) is a leading candidate for conversion to biogas because they possess the highest concentration of substance in a controlled area. According to Lexington-based Phinix Group the state of Kentucky bodes 976 Dairy Farms and 90,000 dairy cows. Assuming a carbon value of \$50 per ton and kilowatt (kw) value of 0.3 per head, each dairy cow in the state has an energy value of \$52, making the potential energy value \$4,680,000 for all dairy cows in the State.

#### ***4.2.1.3 Anaerobic Digestion and Landfill Gas***

As with animal manure, organic waste in landfills also emits concentrated methane and CO<sub>2</sub>. This process occurs as waste in landfills goes through stages of decomposition. Anaerobic digestion can be utilized to recover these emissions just as with Dairy Farms. According to the EPA's Landfill Methane Outreach Program, there are a total of 980 landfills nationwide that would be capable of utilizing such technology.

As solid waste decomposes in a landfill, a gas is created that typically consists of about 50 percent methane and 50 percent CO<sub>2</sub>. The gas can either disperse into the air or be extracted using a series of wells and a blower/flare (or vacuum) system. This system directs the collected gas to a central point where it can be processed and treated. The gas can then be used to generate electricity, heat, or combined heat and power via direct combustion; replace fossil fuels in industrial and manufacturing operations; be upgraded to pipeline quality gas, compressed natural gas (CNG) or liquid natural gas (LNG) for vehicle fuel; or be flared for disposal. As of December 2008, approximately 490 landfill gas (LFG) energy projects were operational in the United States. These 490 projects generate approximately 11 million megawatt-hours (MWh) of electricity per year and deliver more than 230 million cubic feet per day of LFG to direct-use applications. EPA estimates that approximately 520 additional landfills present attractive opportunities for project development (U.S. EPA, 2007a, U.S. EPA, 2009c). Kentucky has five active LFG power plants and a sixth project is under construction. The five active sites have a combined generating capacity of 16 megawatts (EPA, 2008b). DEDI, 2008).

#### ***4.2.2 Thermo-chemical Conversion***

Thermal conversion refers to the breakdown of organic material by combustion in an oxygen-rich atmosphere to heat and carbon dioxide. Traditional pulverized coal power plants utilize thermal conversion. Thermo-chemical conversion uses heat and chemicals in an oxygen-deficient atmosphere to break down organic feedstock into hydrogen and carbon monoxide, commonly referred to as synthesis gas (syngas). Depending upon the process being used, the syngas can be converted to liquid fuels such as ethanol, bio-butanol, methanol, mixed alcohols, or bio-oil (through pyrolysis), or can be burned directly. Thermo-chemical conversion is particularly useful for lignin, which cannot be easily converted to liquid fuels using the biochemical process described above; up to one-third of cellulosic feedstock can be composed of lignin. Forest and mill residue feedstocks generally have high lignin contents, and thus would be more suitable for thermo-chemical conversion than biochemical conversion. This section covers both thermal and thermo-chemical conversion.

#### 4.2.2.1 *Direct Co-firing with Coal*

The most common method to convert biomass to energy is to co-fire biomass in existing coal-fired power plants. However, a number of issues need to be addressed before existing power plants can utilize biomass. Some facilities will require re-permitting by the EPA due to a change in fuel source. The majority of the power plants in Kentucky are older, traditional pulverized coal plants that would likely require significant investment to meet new emissions standards. Modifying these plants could reduce carbon emissions the most, but would likely also be the most difficult and expensive to upgrade to meet regulatory requirements. Newer facilities that utilize fluidized beds may prove easier and less expensive to modify but there are fewer of these sites, resulting in little overall impact on state emissions.

To utilize biomass in power generation, numerous components need to be addressed from the permitting and design changes within the plant to which crop to grow and how it should be harvested, stored, and delivered to an end user. Considerable work has been conducted on individual components, but few examples of an integrated system from field to smokestack have been conducted. Limiting competition with food crops would require utilizing marginal agricultural, abandoned or reclaimed mine land, and woodland areas. Each of these areas has unique challenges in establishing, growing, harvesting, and transporting crops from the land to an end user. While immediate attention should be focused on pilot-scale co-firing investigations for near-term implementation, findings from these pilot scale activities may prove crucial to longer term goals of wide-scale utilization of biomass in gasification and cellulosic ethanol production.

Educational resources exist within the Commonwealth that lend themselves to assisting in co-firing demonstration efforts. Internationally recognized combustion lab facilities at Western Kentucky University provide readily accessible resources and expertise for co-fire testing. Further, faculty at the UK College of Agriculture has provided crucial support in the development of a pilot project to demonstrate biomass co-firing at a Kentucky power plant. However, the following investigations need to proceed:

1. Identify and develop incentives to upgrade the material handling capabilities at a coal fired power plant to allow co-firing of biomass at a rate up to 10%.
2. Produce herbaceous energy crops (switchgrass, Indian grass, big bluestem, and miscanthus giganteus) on underutilized pasture land, abandoned or reclaimed mine land and abandoned agricultural land.
3. Produce woody energy crops (cottonwood, hybrid poplar, and black locust) on underutilized pasture land, abandoned or reclaimed mine land and abandoned agricultural land and investigate the removal of woody residues from forestry operations.
4. Implement a system to co-fire a range of feed stocks available in Kentucky at a coal power plant:
  - a. Develop incentives to allow farms and forests to produce feed stocks for energy production on non-cropland.
  - b. Demonstrate techniques for establishing energy crops on abandoned or reclaimed mine land and other land that requires additional considerations (i.e. deep ripping, rocky, steep slopes, or transplanting).
  - c. Establish and demonstrate effective harvest, storage and transportation practices for herbaceous and woody biomass.
  - d. Document the range in fossil energy, labor, productivity, and cost required to grow, transport and produce electricity from biomass.
5. Co-fire material for a period of five days to evaluate electric power production, emission, and other operational changes due to co-firing biomass.

6. Evaluate alternative practices to improve the sustainability of energy crop production;
  - a. Track changes in soil properties, adaptability to wildlife improvements, and environmental impacts.
  - b. Evaluate the potential of Terra Preta (biochar) for improving and sequestering carbon in energy crop plantations.
7. Determine the overall change in greenhouse gas emissions and cost of electric power from biomass.

A pilot-scale project should be developed to focus on producing biomass on underutilized marginal land in Eastern and Central Kentucky. Experiences with biomass co-firing have indicated that farmers who could grow corn or soybeans would likely change from switchgrass to traditional crops when the economics change.

#### ***4.2.2.2 Gasification and Combustion***

Gasification is a thermo-chemical process that converts a solid fuel to syngas. To create bioenergy, solid biomass feedstocks (e.g., wood waste) are heated above 700 degrees Celsius inside a gasifier with limited oxygen, which converts the feedstock into a flammable, synthesis gas. Depending on the carbon and hydrogen content of the biomass and the gasifier's properties, the heating value of the syngas can range from about 15 to 40 percent of natural gas. Syngas can be burned in a boiler or engine to produce electricity and/or heat. Syngas can also be converted thermo-chemically to a liquid fuel. Gasification has high efficiencies and great potential for small-scale power plant applications. Because the gas can be filtered to remove potential pollutants, the process can produce very low levels of air emissions.

Plasma Arc Gasification is a waste treatment technology that uses the high temperatures of an electrical discharge ("arc") to heat a gas, typically oxygen or nitrogen, to temperatures potentially in excess of 3000 degrees Celsius. The gases heated by the plasma arc come into contact with the waste in a device called a plasma converter and vitrify or melt the inorganic fraction of the waste and gasify the organic and hydrocarbon (e.g., plastic, rubber, etc.) fraction. The extreme heat pulls apart the organic molecular structure of the material to produce a simpler gaseous structure, primarily CO, H<sub>2</sub>, and CO<sub>2</sub>. Plasma arc gasification is intended to be a process for generating electricity, depending upon the composition of input wastes, and for reducing the volumes of waste being sent to landfill sites. Most plasma arc systems are cost effective at only very large scales (1,000,000 tons of feedstock per year or more). A number of companies are working on the development and deployment of this emerging technology.

The combination of a gasifier with a combined cycle electric conversion system is viewed by many as one of the more promising technology combinations for future generation of electricity and/or heat and power (CHP.) At larger scales, the advances being made in gas turbine technologies offer substantial potential for more efficient electrical generation than other technologies. (Western Governors Association, 2006)

Combined heat and power can also serve as a means to reduce the cost of generation for any fuel. Low grade heat rejected in the power generation process and sent to a condenser can instead be used as process heat for industrial applications. Cogeneration is also a form of CHP, and is used primarily with thermal conversion technologies.

#### ***4.2.2.3 Gasification to Liquid***

As stated above gasification can also be applied to the production of liquid fuels from thermo-chemical process. Fischer-Tropsch is the most common process that rearranges the molecular structure of syngas to various liquid fuels. This process is being rapidly developed by the Department of Defense, and is the basic technology for coal to liquids applications.

Pyrolysis is another thermo-chemical process that uses high temperatures and pressure in the absence of oxygen to decompose organic components in biomass into gas, liquid (bio-oil), and char products (bio-char). The process occurs at lower temperatures than combustion or gasification. Controlling the temperature and reaction rate determines product composition.

Bio-oil is an acidic complex mixture of oxygenated hydrocarbons with high water content. Most data and research come from the pyrolysis of wood, although it is possible to convert any biomass feedstock into bio-oil through pyrolysis. Bio-oil's composition is influenced by several factors: feedstock properties, heat transfer rate, reaction time, temperature history of vapors, efficiency of char removal, condensation equipment, water content, and storage conditions. Bio-oil can be used for producing thermal energy (e.g., for heating buildings, water, and in industrial processes), for power generation using slow-speed diesel engines or combustion turbines, and for cofiring in utility-scale boilers. Bio-oil cannot be used as a transportation fuel without further refining.

The energy content of bio-oil ranges from 72,000 to 80,000 Btu per gallon whereas conventional heating oil (No. 2) has an energy content of about 138,500 Btu per gallon. Thus, bio-oil contains about 52 to 58 percent as much energy and almost twice as much bio-oil is required to produce the same amount of heat as No. 2 heating oil. In addition, bio-oil weighs about 40 percent more per gallon than heating oil. A coproduct of producing bio-oil is char or bio-char. (Western Governors Association, 2006)

### ***4.3 Findings and Conclusions***

1. The sustainable production of 25 million tons of biomass per year cannot occur without significant improvements in yield and adaptability of biomass.
2. While Kentucky's educational institutions have already sponsored a small degree of research into genetic and productivity improvements for biomass, a considerable increase in this type of research is required.
3. It is necessary that public-private partnerships be developed that leverage existing research and reduce the time to commercialization.

## BUSINESS STRUCTURES

***“Evaluate available business structures in Kentucky, including structures that allow direct producer ownership, and formulate plans of action that allow adequate capitalization of a new biomass industry.”***

### 5.1 Overview

Maximum economic benefit from a Kentucky biomass industry for rural producers can only occur as producers participate in higher levels of the biomass supply chain. A New Generation Cooperative (NGC) is a relatively new type of cooperative used primarily in the value-added processing of agricultural commodities that allows this participation. First used in the upper Midwest in the early 1970s, the NGC organizational form became popular in the early- to mid-1990s for producers interested in collectively adding value to their commodities. The NGC model has since been used for hundreds of new cooperatives across the United States, but has not yet been used extensively in Kentucky.

### 5.2 New Generation Cooperatives

The NGC is not a specific legal structure. Rather, the term New Generation Cooperative is used to describe how a firm operates. It primarily describes the relationship between the firm and its members and how the firm is financed. Unlike traditional cooperatives, in which start-up expenses are minimal and growth is financed through members' retained earnings, permanent equity to fund NGC start-up and growth is financed through the sale of delivery rights. These delivery rights represent a member's right to deliver a specific amount of commodities to the cooperative. Members benefit in proportion to their use, and nearly all NGCs are democratically controlled through one member/one vote.

There are six primary characteristics of NGCs:

1. **Defined membership.** Frequently, NGCs are referred to as closed cooperatives. The number of members in an NGC depends upon the proposed capacity of the cooperative's operations. One of the key features of the NGC is its ability to control supply or access to the cooperative's operations. In other types of cooperatives, members can enter and exit as they please, and cooperatives operating without marketing contracts with their members have no way to guarantee a specific operating capacity at any one time. By limiting membership to those members who purchase the right to supply the cooperative, the NGC is able to ensure a steady supply of the agricultural inputs required for running operations at the most efficient level possible. In an NGC, the membership is generally not permanently closed. If the cooperative decides to expand production, for example, it could seek equity from producers outside the initial membership.
2. **Delivery rights:** a right and an obligation to deliver. Once members contribute equity toward the NGC, they receive the right, and the obligation, to deliver a specific quantity of the commodity each year. This means if producers have purchased the right to deliver 500 tons of biomass each year, they must deliver 500 tons—no more, no less. If they cannot deliver that amount or if the commodity does not meet the quality standards set forth in the marketing agreement, the cooperative may have the right to buy the commodity on the producers' behalf and charge for the difference in price.
3. **Upfront equity required from producers.** Adding value to agricultural and forestry commodities can be capital-intensive. Before lending money to a project, banks and other lending institutions will require producers to raise part of the project cost. Often, this means producers must raise 50 percent or more of the total project cost. If the project is estimated to cost \$1 million, for example, producers will need to raise \$500,000 or more. Although it may be possible to find private investors to reach the required equity level, producers are often the sole source of equity. As a

way to tie members' use to the total project equity required, the total amount to be raised is broken into smaller units. These units are tied to the amount of product required to be delivered. A market feasibility study will help determine the most economically efficient size for the processing facility. Once you know the amount of commodities the plant will require each year, you should then determine how to allocate this total amount into shares. For example, if the most efficient size plant requires one million bushels of soybeans a year, you should divide one million into a specific number of shares. To determine the specific number of shares, you should set minimum and maximum amounts of delivery rights to be purchased. To determine this, you need to balance two issues: how many producers do you want involved in the business and what is financially viable for you and other producers to commit.

4. Delivery rights are transferable and may fluctuate in value. The delivery right is similar to a share of corporate stock because it represents a firm's permanent equity. As with a share of corporate stock, the value of your delivery right will depend on your firm's profitability. If an NGC is successful and provides value for its members, the delivery right may appreciate in value. If the NGC does not provide value to its members, the value of the delivery right may decrease. Unlike stock in a public corporation, however, the delivery right has a very limited resale or trading market. To comply with antitrust, securities, tax, and incorporation statutes, NGC bylaws limit transfer to other producers and usually require the board of directors to approve any transfer.

5. Marketing agreement entered into between member and cooperative. Upon purchasing delivery rights, members are required to sign a marketing contract outlining the duties of both the members and the cooperative toward each other with respect to the delivery, quality, and quantity of producers' commodities. These contracts are usually evergreen contracts, meaning they are for specified periods of time (from one to five years). They are renewed automatically unless either party gives notice to the other within a window of time specified in the marketing agreement. The marketing agreement often specifies the high quality standards required of members' commodities, especially in cooperatives producing consumer-level goods. The marketing agreement outlines the specific quality required to be delivered, how quality will be measured, and the producer's rights and obligations if the quality standard is not met.

6. Members and their NGC share three primary legal relationships.

- Members must purchase a share of common stock or other membership interest to enable them to vote in all decisions set forth in the bylaws.
- Members also purchase delivery rights, which are both a right and an obligation to deliver. The delivery rights are evidenced by legal documentation and are usually transferable upon approval from the board of directors.
- Finally, members must sign a marketing agreement when purchasing delivery rights and voting stock. The marketing agreement defines the rights and obligations of both the member and cooperative toward each other with respect to the delivery of commodities from the member to the cooperative.

As a result, members must pay money to the cooperative for both the voting stock (usually very minimal) and the delivery rights (amount varies on project size, minimum and maximum purchase requirements, and the specific amount of commodity to be delivered by the member). Members also are required to deliver the specified quality and quantity of commodities at pre-specified intervals for the length of the marketing agreement (which is usually, through evergreen contracts, perpetual in nature). The cooperative, in turn, is required to pay members a pre-specified price for the commodities delivered (usually a formula price based on spot market prices at a specified exchange, with additions or subtractions based on quality). The cooperative also is required to return any profits to members on a pre-specified schedule determined by the board of directors. Depending on operating cash requirements, the timeline for returning profits could be immediately. Due to securities law issues, cooperatives are not actively involved in the transfer of delivery rights. The cooperative usually requires approval from the board of directors before any transfer is complete, and sometimes an outside broker handles the actual transfer of delivery rights. (Hackman, Missouri Department of Agriculture, 2001)

### ***5.3 Findings and Conclusions***

1. Keeping the biomass supply chain ownership with producers is one of the most effective methods of retaining the rural economic benefits of biomass development.
2. Business structures that utilize producer-owned cooperatives and partnerships have been the most successful means of creating economic prosperity throughout small Midwestern communities.
3. The ability to pool agriculture producers' and forest landowners' funds through closed cooperatives is an effective method for capitalization of production, densification, handling and processing systems focusing on regionalization.
4. While Kentucky hasn't traditionally utilized closed cooperative structures in the past, this business structure contributes to capitalization of a new biomass industry.

## ECONOMIC EFFECTS OF A KENTUCKY BIOMASS / BIOFUELS INDUSTRY

*“Facilitate economic impact analysis of the effect of a biomass and biofuels industry on Kentucky.”*

### 6.1 Economic Impact Summary

Examples of projected primary economic effects of a focused and integrated Kentucky Biomass / Biofuels Industry through 2025 are summarized as follows:

- Increase biomass feedstock utilization from 3 to 5 million tons (MT) per year to an estimated 25 MT per year.
- Convert 2 million acres or 15% of Kentucky’s farmland from low-valued forage and hay production to higher valued energy crops.
- Replace agricultural income lost from declining crops such as tobacco.
- Establish significant levels of public-private partnerships to design, build, and operate new farm to market processes.
- Expand gross state product (the value of goods and services produced in Kentucky) by \$2.5 to \$3.4 billion per year, creating an estimated 10,000 new permanent operations jobs statewide in various phases of biomass and biofuels related industries when biomass feedstock utilization reaches 25 MT per year.
- Establish significant public and private investments in infrastructure construction and modification, new processing systems, and biofuel production facilities which could cost as much as \$10 billion and could support as many as 14,000 temporary construction jobs.
- Increase statewide education, workforce development, and economic development activities to support a fast growing biomass and biofuels industry and infrastructure.
- Contribute to evolving economic benefits from carbon offset credits as a result of using more biomass-based fuels and less carbon-based fuels in both the power production and transportation sectors.

This industry has potential to involve and/or impact every citizen, family, land owner, business owner, government agency and officials, college and university, utility, investor, financial organization, and many other stakeholders in establishing a worldwide example of stewardship and innovation in the Commonwealth of Kentucky.

This is not a new industry, however, it needs a new integrated strategy. Today there are shining examples in Kentucky of innovation and progress started and sustained by private and public efforts, however, these are mostly isolated developments. The Commonwealth has an opportunity to build on those existing examples and leverage those efforts with new interest, focus, investments, and strategies to create a dynamic integrated industry for the future benefit of all.



## 6.2 Monetizing the Benefits of Biomass to Communities

Dr. Craig Infanger of the University of Kentucky, College of Agriculture, and the Biomass Energy Impact Study Group presented their findings to the Task Force on October 14, 2009. A summary of findings of preliminary analysis of the impacts and consequences of large-scale biomass utilization is shown in the table below. The approach was to analyze the potential economic impacts of three different levels of large-scale biomass utilization and biofuel processing. The research team applied conventional economic impact analysis (IMPLAN) using Kentucky specific economic sector data and economic multipliers.

Scenario I represents an initial large-scale feedstock utilization rate of 5 million tons per year composed of agricultural wastes and forest industry waste, utilized entirely for co-firing electrical generation at existing power plants. Scenario II represents an expanded large-scale biomass utilization rate of 15 million tons per year, which can be reached only through significant production of energy crops (5 MT/yr) and securing forest harvest waste plus woody biomass production. Finally, Scenario III analyzes a biomass utilization rate of 25 million tons per year by 2022 which will be possible only with an additional 10 MT per year of energy crop production.

Assumptions for each Scenario are as follows:

Scenario I:

- Agricultural residue is primarily corn stover (round bales).
- Wood waste is forest harvest residue (chips).
- Feedstock is sourced in Kentucky.
- Electricity generation is based on five coal-fired electric plants retro-fitted for biomass co-firing.
- Transportation is direct to the power generation locations.

Scenario II:

- Maximum sustainable forest waste and harvest utilization (~7.5 million tons per year).
- A portfolio of energy crops contributes an additional 5 million tons per year.
- 100 collection & densification plants for agricultural and forest waste.
- Four 50 million gallons per year (MGY) and two 100 MGY cellulosic ethanol plants.
- No major logistical constraints exist.
- No imports or exports of biomass.

Scenario III:

- Additional biomass from energy crops of +10 million tons per year to reach the 25 million tons per year biomass feedstock utilization goal.
- Yields on portfolio of energy crops rise 35%.
- One additional very large scale ethanol plant (200 MGY).
- No major logistical constraints exist.
- No imports or exports of biomass.

Expansion of biomass utilization will have, as shown in Scenarios II and III below, some impacts on land use in agriculture and especially on the forage-based livestock industry.

## Preliminary Economic Impact and Consequences of Large Scale Biomass Energy Production in Kentucky

Dr. Craig Infanger, University of Kentucky - College of Agriculture

Biomass Energy Impact Study Group

### Related Benefits of Each Scenario:

Sources	Uses	Scenario I (5 MT / Yr.)	Scenario II (15 MT / Yr.)	Scenario III (25 MT / Yr.)
Estimated Biomass Utilization				
Agricultural Waste	100% Co-Firing for Electricity	2.5 MT	2.5 MT	2.5 MT
Forest Waste		2.5 MT	2.5 MT	2.5 MT
Energy Crop - 70% Switchgrass + 30% Miscanthus	50% Ethanol + 50% Co-Firing for Electricity		5.0 MT	15.0 MT
Forest Harvest + Woody Biomass			5.0 MT	5.0 MT
Total Ag and Forest Waste		5.0 MT	15.0 MT	25.0 MT
Energy Potential				
Estimated Ethanol Production		0	400 MG	600 MG
Estimated Biomass Power - (Coal Equivalent)		3.6 MT	7.2 MT	9.1 MT
Probable Economic Impacts - Construction Phase				
Employment Changes		146 -293	2,755 - 8,794	5,793 - 13,860
Direct Output Impacts		\$16 M - \$32 M	\$280 M - \$479 M	\$601 M - \$984 M
Probable Economic Impacts - Operation Phase				
Employment Changes		648 -792	6,404 - 7,828	8,178 - 9,996
Direct Output Impacts		\$193 M - \$236 M	\$1.19 B - \$1.49 B	\$1.79 B - \$1.93 B
Estimated Impact on Gross State Output		\$302 M - \$370 M	\$1.95 B - \$2.49 B	\$2.55 B - \$3.42 B

### Related Consequences of Each Scenario:

Land Use Conversion - Acres				
Hay		0	250 K - 400 K	723 K - 883 K
Pasture		0	470 K - 550 K	719 K - 879 K
Cropland		0	40 K - 80 K	118 K - 144 K
Total Ag Land		0	780 K - 1.01 M	1.98 M - 2.42 M
Livestock Production Impacts				
Cow Equivalent Loss		0	285 K - 348 K	627 K - 767 K
Livestock Revenue Loss		0	\$139 M - \$171 M	\$306 M - \$374 M

Wide-scale energy crop and woody biomass production on Kentucky farms may lead to conversion of current pasture and hay land as well as a small amount of low productivity cropland, if the prices for biomass are high enough to encourage private production. When biomass utilization reaches the goal of 25 MT per year and assuming biotech improvements in yields of switchgrass and miscanthus raise average on-farm yields by 35% over current levels, as much as 2,400,000 acres of agricultural land might be converted to energy crops and woody biomass. If on-farm energy crops yield increases are less than 35% over the near term, then land use changes in agriculture will have to be larger in order to meet the 25 MT per year goal. These land use shifts are consistent with USDA studies on biofuel production.

Large-scale energy crop production and the associated land use conversion in agriculture will primarily impact the livestock industry. In 2008, the livestock industry generated \$2.9 billion in animal and product sales. Conversion of pasture and hayland to energy crops and woody biomass will consequently reduce animal numbers, primarily beef cow herd size. It was estimated in the UK study that the cow-equivalent loss of converting 2,400,000 acres of pasture and hayland to energy crops could be in the range of 600,000 - 750,000 head and the reduction in livestock revenue could be \$300 million to \$374 million per year.

### ***6.3 Biomass as a Distributed Income Source***

Revenue streams from an expanded and integrated biomass industry occur at many levels including; propagator, land owner/grower, harvester, local transporter, processor, consolidator, mass transporter, buyer/user, power/fuel consumers. At each level there are many additional revenue and management opportunities depending on the tendencies of larger operators to outsource or insource labor components. Either way jobs are created to construct facilities to build out the industry and to operate processes and systems in support of small and large operators.

Due to the logistics and distances to end processors such as power generators or clean fuels processing plants, the cost of transportation will drive some concentration of growing and harvesting operations around end processor locations. However, economies of scale in transportation and logistics and an estimated 100 distributed processing plants and closed cooperative business structures mitigate those issues and allow for most land owners in Kentucky to participate. This is a powerful economic driver that results in a broad and profitable network of participants across the Commonwealth. No landowner, county, municipality, or business owner that has resources to participate in this industry would be prevented unless unfavorable economic conditions become a barrier.

The Task Force envisions that all 120 counties in the Commonwealth will have positive opportunities to participate either in agriculture, energy, or both. Most will have at least one local collection and densification and/or processing plant. All should have the opportunity to generate new revenue from growing, sales, transportation, and other support operations. Small and large operators will co-exist. Existing resources and equipment can be used for new crops and processes.

Opportunities for access and participation in the biomass and biofuels industry in Kentucky are available and increasing. One of the keys to success and a path to increase stakeholder access to this industry is the combination of education, workforce development, and economic development. To successfully move forward business development requires multiple perspectives and understanding. Increasing available knowledge of opportunities, training others to successfully seek out those opportunities, and establishing a business environment that is supportive and focused on making those opportunities increasingly available in the Commonwealth of Kentucky will provide access to all who want to participate and benefit. Integrated and focused development will support prospective investors and lenders in increasing confidence in their investments due to reduced environmental challenges, faster permitting, shorter construction periods, and therefore, a quicker revenue stream.

## ***6.4 Findings and Conclusions***

1. The development of a biomass and biofuels industry in Kentucky can create significant economic activity in every community of the Commonwealth.
2. At 25 MT per year utilization level, the updated biofuels industry will have major impacts on agriculture, transportation, electric generation, and employment in Kentucky.
3. It is estimated that biomass and biofuels production can generate an estimated \$2.55 to \$3.4 billion of new value added net output annually along with almost 10,000 new permanent operations jobs, most of which will be in the transportation and logistics sectors and concentrated within rural communities statewide.
4. The development of 25 million tons per year biomass and biofuels industry will require private and public capital investments in excess of \$10 billion and could support as many as 10,000 permanent jobs.
5. Successful development will require a high level of public-private partnerships.
6. Advancements in biomass development will help prepare the Commonwealth to positively participate in expected carbon offset trading.

## STRATEGIC ACTIONS and RECOMMENDATIONS

### ***“Recommend legislative (or other) action that supports development of a biomass and biofuels industry.”***

The Governor’s Executive Task Force on Biomass and Biofuels Development has accomplished a macroscopic analysis of a Kentucky biomass industry, and has served to elevate awareness of the economic and environmental benefits of biomass and biofuels production. To sustain the efforts of the Task Force, a detailed plan and roadmap for development of an industry of the magnitude of biomass must still be developed. The recommendations of the Task Force, therefore, not only lay out specific requirements that are prerequisite to building a biomass industry, but also the requirements for continuing activities that will allow for the creation of this roadmap. In summarizing its findings the Task Force has arrived at five strategic actions which form the basis for recommendations to Governor Beshear. Recommendations have been included that are preferential but may not require legislative action. Recommendations should be considered in their entirety, and are not listed by relative order of importance.

### ***7.1 Kentucky must identify a single agency to coordinate biomass development efforts***

- The Task Force recommends that the Division of Biofuels within the Energy and Environment Cabinet serve as a single agency point to coordinate and facilitate biomass and biofuels development statewide. The Division of Biofuels must be fully integrated with the Governor’s Office of Agricultural Policy, Department of Agriculture, Cabinet for Economic Development, Division of Forestry, and agency representatives of Workforce Development, whether by formal or informal structure, to facilitate the merger of the biomass provisions of Kentucky’s strategic plan for energy and its strategic plan for agriculture into a Roadmap for Biomass Development to 2025. There appears to be no existing model coordinating the need for innovation, cooperative regional collaborations, the importance of research and development and leveraging geographical resources. Therefore, the Roadmap must identify necessary actions, streamlining administration and maximizing any government investment while recognizing success.
- As Kentucky returns to economic health and as funding becomes available, the Task Force recommends that a Kentucky Center for Biomass Advancement and Research be established that will serve to consolidate regional synergies and developing technologies into a unified direction of biomass development for the Commonwealth.
- The Task Force recommends that the Kentucky Department of Agriculture incorporate biomass and biofuel development awareness into its Kentucky Proud or similar marketing plan.

### ***7.2 Kentucky must develop policies to mitigate demand risks***

- The Task Force recommends that a Kentucky-specific Renewable and Efficiency Portfolio Standard be mandated, which will provide significant opportunities for biomass and job development in Kentucky. This standard should consider our existing natural resources and incorporate plans for workforce development. It is highly probable that a Federal Renewable Portfolio Standard will be mandated. In this event renewable energy in Kentucky without biomass will likely be provided by out-of-state sources such as wind from the Midwest, leaving Kentucky with higher costs of electricity but no economic stimulus from renewable energy production.

### ***7.3 Kentucky must develop policies to mitigate supply risks***

- A baseline for biomass development is already established by the successful start of numerous private companies, as well as the initiation of significant public and private research. However, in order to foster the development of biomass production and to stimulate the development of a biomass-based liquid fuel and power industry, markets must be more specifically identified and projected. Therefore, the Task Force recommends that the Division of Biofuels publish analyses and summary findings identifying current biomass development and technology within the Commonwealth, along with demand projected from developing technologies and mandates. Research related to biomass and biofuel, pilot research facilities and research sites to grow different potential feedstocks, use of wood pellets and wood byproducts as sources of feedstock, and analyses for best crop determination should be highlighted.
- Education for agriculture producers and forest land owners on the use of cooperative business structures for value-added processing is crucial to biomass development in Kentucky. It is apparent that these business structures provide inherent benefits to producers including collective capitalization, tax credit utilization and producer collaboration. The Task Force recommends that the Board of Directors of the Kentucky Center for Agriculture and Rural Development (KCARD) in Elizabethtown realign its objectives to include the education of producers and forest owners on the benefits and availability of closed cooperative business structures for value-added processing, and that KCARD serve as facilitator in the implementation of this business structure for biomass development.

### ***7.4 A biomass industry that is sustainable must be developed***

- The Task Force recommends that the Division of Biofuels in collaboration with stakeholder groups facilitate development of a Kentucky Standard for Biomass Sustainability. This standard must factor in continuous improvements in production, processing and management technologies that will be required for future development.

## *7.5 Capitalization mechanisms must be developed*

- The Task Force recommends that the Governor's Office of Agricultural Policy and the Energy and Environment Cabinet assess public opinion of funding mechanisms that foster the development of biomass production and that stimulate the development of a biomass-based liquid fuel and power industry. The Task Force recognizes that while the establishment of potential future funding mechanisms will largely depend upon the economic health of the Commonwealth, the following are examples that could be considered:
  1. Establishment of a renewable energy fee on all electricity sold in Kentucky. For every one-tenth of a cent per kwh, approximately \$100 million could be generated to support efforts to develop a biomass industry. The revenue could be dedicated to funding a public benefits fund established for the development of renewable energy, and/or enabling the electric power industry to make investments that will be needed in meeting the requirements of a Renewable and Efficiency Portfolio Standard. The public benefits fund could also dedicate a percentage of its annual revenue to the Kentucky Agricultural Finance Corporation for its revolving loan fund that could be used to assist in the establishment of energy crop systems in agriculture and forestry, including planting, harvesting, densification and transfer.
  2. Redirection of one-half of the 1.4 cent per gallon of gasoline assessment for the Petroleum Storage Tank Environmental Assurance Fund (PSTEAF) to a new program to generate \$20-25 million a year to advance new energy technologies.
  3. Revision of existing biofuel incentives found in KRS Chapter 141 to enable up to \$1 million of tax credits per entity be made transferrable. Existing statutes allow for a tax credit of one dollar per gallon of biodiesel/ethanol produced or blended, and are not transferrable.
  4. Utilizing the resources of the Division of Biofuels, development of a program that can inform the public of the availability of federal loans and grants, and that can assist them in the application process.

## GLOSSARY of TERMS

### A

**agricultural residue:** Plant parts, primarily stalks and leaves, not removed from fields with the primary food or fiber product. Examples include corn stover (stalks, leaves, husks, and cobs), wheat straw, and rice straw.

**algae:** Simple photosynthetic plants containing chlorophyll, often fast growing and able to live in freshwater, seawater, or damp soils. May be unicellular and microscopic or very large, as in the giant kelps.

**anaerobic:** Living or active in an airless environment.

**anaerobic digestion:** Degradation of organic matter by microbes in the absence of oxygen to produce methane and CO<sub>2</sub>.

### B

**biodiesel:** Biodegradable transportation fuel used in diesel engines. Biodiesel is produced through transesterification of organically derived oils and fats. It may be used either as a replacement for or component of diesel fuel.

**bioenergy:** Renewable energy produced from biomass.

**biofuels:** Fuels for transportation made from biomass or its derivatives after processing. The major biofuels include ethanol and biodiesel.

**biogas:** Gaseous mixture of CO<sub>2</sub> and methane produced by anaerobic digestion of organic matter.

**biomass:** Any plant-derived organic matter. Biomass available for energy on a sustainable basis includes herbaceous and woody energy crops, agricultural food and feed crops, agricultural crop wastes and residues, wood wastes and residues, aquatic plants, and other waste materials, including some municipal wastes.

**biopower:** Use of biomass to produce electricity and heat.

**bioproducts:** Commercial or industrial products (other than food or feed) that are composed in whole or significant part of biomass.

### C

**carbohydrate:** Organic compounds made up of carbon, hydrogen, and oxygen and having approximately the formula (CH<sub>2</sub>O)<sub>n</sub>; includes cellulose, starches, and sugars.

**carbon dioxide:** (CO<sub>2</sub>) Naturally occurring gas, and also a by-product of burning fossil fuels and biomass, as well as land use changes and other industrial processes. It is the principal anthropogenic GHG that affects the earth's radiative balance.

**carbon monoxide:** (CO) Colorless, odorless, poisonous gas produced by incomplete combustion.

**catalyst:** Substance that increases the rate of a chemical reaction without being consumed or produced by the reaction. Enzymes are catalysts for many biochemical reactions.

**cellulase:** Family of enzymes that break down cellulose into glucose molecules.

**cellulose:** Carbohydrate that is the principal constituent of wood and other biomass and forms the structural framework of the wood cells.

**chips:** Small fragments of wood chopped or broken by mechanical equipment. Total tree chips include wood, bark, and foliage. Pulp chips or clean chips are free of bark and foliage.

**cofiring:** Use of a mixture of two fuels within the same combustion chamber.

**cogeneration:** Technology of producing electric energy and another form of useful energy (usually thermal) for industrial, commercial, or domestic heating or cooling purposes through sequential use of the energy source. Also called combined heat and power (CHP).

**combustion:** Chemical reaction between a fuel and oxygen that produces heat (and usually light).

**coproducts:** Resulting substances and materials that accompany production of a fuel product such as ethanol.

**corn stover:** Refuse of a corn crop after the grain is harvested.

**criteria pollutants:** Pollutants regulated under the federal NAAQS, which were established under the Clean Air Act. Criteria pollutants include CO, lead, nitrogen dioxide, PM (PM<sub>2.5</sub>, PM<sub>10</sub>), ground-level ozone, and SO<sub>2</sub>.

## D

**digester:** Biochemical reactor in which anaerobic bacteria are used to decompose biomass or organic wastes into methane and CO<sub>2</sub>.

## E

**E10:** Mixture of 10 percent ethanol and 90 percent gasoline based on volume.

**E85:** Mixture of 85 percent ethanol and 15 percent gasoline based on volume.

**effluent:** Liquid or gas discharged after processing activities, usually containing residues from such use. Also discharge from a chemical reactor.

**energy crop:** Crop grown specifically for its fuel value. These include food crops such as corn and sugar cane, and nonfood crops such as poplar trees and switchgrass.

**enzyme:** Protein or protein-based molecule that speeds up chemical reactions in living things. Enzymes act as catalysts for a single reaction, converting a specific set of reactants into specific products.

**ester:** Compound formed from the reaction between an acid and an alcohol.

**ethanol:** ( $\text{CH}_3\text{CH}_2\text{OH}$ ) A colorless, flammable liquid produced by fermentation of sugars. Ethanol is used as a fuel oxygenate. Ethanol is the alcohol found in alcoholic beverages, but is denatured for fuel use.

**eutrophic conditions:** In surface waters, conditions such as significant algae growth and subsequent oxygen depletion, which can be caused by excessive nutrients from fertilizers, pesticides, and herbicides. Some aquatic species cannot survive eutrophic conditions.

## F

**feedstock:** Any material used as a fuel directly or converted to another form of fuel or energy product.

**fermentation:** Biochemical reaction that breaks down complex organic molecules (such as carbohydrates) into simpler materials (such as ethanol,  $\text{CO}_2$ , and water). Bacteria or yeasts can ferment sugars to ethanol.

**fluidized bed:** Gasifier or combustor design in which feedstock particles are kept in suspension by a bed of solids kept in motion by a rising column of gas. The fluidized bed produces approximately isothermal conditions with high heat transfer between the particles and gases.

**forestry residues:** Includes tops, limbs, and other woody material not removed in forest harvesting operations in commercial hardwood and softwood stands, as well as woody material resulting from forest management such as precommercial thinnings and removal of dead and dying trees.

**fossil fuel:** Carbon or hydrocarbon fuel formed in the ground over millions of years from the remains of dead plants and animals. Oil, natural gas, and coal are fossil fuels.

## G

**gasification:** Any chemical or heat process used to convert a feedstock to a gaseous fuel.

**greenhouse gas:** Gas—such as water vapor,  $\text{CO}_2$ , tropospheric ozone, methane, and low-level ozone—that contributes to the greenhouse effect.

## H

**hemicellulose:** Hemicellulose consists of short, highly branched chains of sugars. In contrast to cellulose, which is a polymer of only glucose, a hemicellulose is a polymer of five different sugars.

**herbaceous plants:** Non-woody species of vegetation, usually of low lignin content, such as grasses.

**herbaceous energy crops:** Perennial non-woody crops that are harvested annually, though they may take two to three years to reach full productivity. Examples include switchgrass (*Panicum virgatum*), reed canary grass (*Phalaris arundinacea*), miscanthus (*Miscanthus x giganteus*), and giant reed (*Arundo donax*).

**hydrolysis:** Conversion, by reaction with water, of a complex substance into two or more smaller units, such as conversion of cellulose into glucose sugar units.

## L

**landfill gas:** Biogas produced from natural degradation of organic material in landfills. By volume, LFG is about 50 percent methane and 50 percent CO<sub>2</sub> and water vapor.

**life-cycle analysis:** Assessment of the impacts from all stages of a product's development, from extraction of fuel for power to production, marketing, use, and disposal.

**lignin:** Structural constituent of wood and other native plant material that encrusts the cell walls and cements the cells together.

**lignocellulose:** Plant materials made up primarily of lignin, cellulose, and hemicellulose.

## M

**methane:** (CH<sub>4</sub>) The major component of natural gas. It can be formed by anaerobic digestion of biomass or gasification of coal or biomass.

**methanol (wood alcohol):** (CH<sub>3</sub>OH) Alcohol formed by catalytically combining carbon monoxide with hydrogen in a 1:2 ratio under high temperature and pressure.

**microorganism:** Any microscopic organism such as yeast, bacteria, fungi, etc.

**municipal solid waste:** Any organic matter, including sewage, industrial, and commercial wastes, from municipal waste collection systems. Municipal waste does not include agricultural and wood wastes or residues.

## N

**net energy balance:** Total amount of energy used over the full life cycle of a fuel, from feedstock production to end use.

**nitrogen oxides:** (NO<sub>x</sub>) Product of photochemical reactions of nitric oxide in ambient air, and the major component of photochemical smog.

**nonrenewable resource:** One that cannot be replaced as it is used. Although fossil fuels, such as coal and oil, are in fact fossilized biomass resources, they form at such a slow rate that, in practice, they are nonrenewable.

## O

**opportunity fuels:** Biomass feedstocks derived from waste materials that would otherwise go unused or would be disposed of. Bioenergy production provides an opportunity to productively use these materials.

**oxygenate:** Compound that contains oxygen in its molecular structure. Ethanol and biodiesel act as oxygenates when they are blended with conventional fuels. Oxygenated fuel improves combustion efficiency and reduces tailpipe emissions of CO.

## P

**particulates:** Fine liquid or solid particle, such as dust, smoke, mist, fumes, or smog, found in air or emissions.

**petroleum:** Any substance composed of a complex blend of hydrocarbons derived from crude oil, including motor fuel, jet oil, lubricants, petroleum solvents, and used oil.

**pyrolysis:** Breaking apart of complex molecules by heating in the absence of oxygen, producing solid, liquid, and gaseous fuels.

## R

**renewable energy resource:** Energy resources that can be replaced as they are used, including solar, wind, geothermal, hydro, and biomass. MSW is also considered a renewable energy resource.

**residues, biomass:** By-products from processing all forms of biomass that have significant energy potential. For example, making solid wood products and pulp from logs produces bark, shavings, sawdust, and spent pulping liquors. Because these residues are already collected at the point of processing, they can be convenient and relatively inexpensive sources of biomass for energy.

## S

**silviculture:** Science and practice of growing trees for human use.

**stover:** Dried stalks and leaves of a crop remaining after the grain has been harvested.

**syngas:** Synthesis gas produced by the gasification process using biomass feedstock. Syngas can be burned in a boiler or engine to produce electricity or heat, and can be used to produce a liquid for biofuels production.

## T

**tar:** Liquid product of thermal processing of carbonaceous materials.

**thermochemical conversion:** Use of heat to change substances chemically to produce energy products.

**transesterification:** Chemical process that reacts an alcohol with triglycerides contained in vegetable oils and animal fats to produce biodiesel and glycerin.

## V

**volatile:** Solid or liquid material that easily vaporizes.

## X

**xylose:** (C<sub>5</sub>H<sub>10</sub>O<sub>5</sub>) Five-carbon sugar that is a product of hydrolysis of xylan found in the hemicellulose fraction of biomass.

## **Z**

**zero net contribution:** Refers to a process that results in contribution of no additional carbon emissions to the atmosphere. For example, combustion of biomass feedstocks returns the same amount of CO<sub>2</sub> to the atmosphere that was absorbed during growth of the biomass, resulting in no additional CO<sub>2</sub> released into the air.

Source: Adapted from National Renewable Energy Laboratory (NREL) Glossary of Biomass Terms, [www.nrel.gov/biomass/glossary](http://www.nrel.gov/biomass/glossary).

## APPENDIX I

# WHITE PAPER FOR GOVERNOR BESHEAR'S APPOINTMENT OF A TASK FORCE ON BIOMASS/BIOFUELS IN KENTUCKY

## A collaborative effort of the Governor's Office of Agricultural Policy and the Energy and Environment Cabinet

### The Challenge

Governor Beshear's energy plan, *Intelligent Energy Choices for Kentucky's Future*, establishes specific goals for the development of a biomass and biofuels industry. Numerous efforts by organizations to stimulate the development of biomass production and processing have been ongoing for several years and significant dialogue has occurred throughout the Commonwealth. Kentucky's General Assembly has passed energy legislation that provides income tax relief for biofuels producers and financial incentives for energy developers. However, these significant efforts have yet to translate into meaningful and sustainable growth of either biofuels production or biomass for power generation.

This lack of development is even more concerning when consideration is given to the renewable fuels demand created by the federally mandated Renewable Fuels Standard (RFS), and to the potential effect of a looming federal Renewable Portfolio Standard (RPS) for electricity. As a result of the 2006 RFS mandate, Kentucky consumers now use 10 percent biofuels in over 70 percent of their gasoline. However, only 24 percent of the biofuels currently consumed is produced instate with the balance being imported primarily from the Midwest. As the mandate expands over the next 13 years, the average biofuels blend rate will increase to over 25 percent further increasing our need for biofuels imports. This will increase Kentucky's demand for biofuels from 150 million gallons to 775 million gallons per year. If Kentucky fails to expand its biofuels production, the Commonwealth will import nearly 90 percent of its renewable fuels in 2022, the final year of RFS expansion.

A 20% federally mandated RPS would require that Kentuckians be supplied with approximately 20 million megawatt-hours (mwh) of electricity generated from renewable energy sources. This translates into 2400 megawatts of electric power generation capacity. Since Kentucky is not geographically advantaged for base-load wind and solar power generation, it is expected that an RPS mandate would be met primarily through biomass co-firing and importing renewable electricity from upper Midwestern states. To achieve the RPS, Kentucky will be forced to compete against other states for limited renewable electricity resources, which will have a profound negative impact on our electric rates.

Should Kentucky continue with importing transportation biofuels and electricity from renewable energy sources, it will no longer be able to effectively compete with other states for energy-intensive industries. However, if Kentucky chooses to follow the Governor's energy plan which encompasses utilization of the Commonwealth's abundant biomass resources to produce biofuels and generate renewable energy, there will remain only a few states that will be as competitive.

### **The Opportunity**

Kentucky's Strategy for Energy Independence calls for 12 percent of its transportation fuels to be renewable by 2025, and to be provided by in-state production. With ethanol and biodiesel production capacity currently at approximately 90 million gallons per year, an additional 700 million gallons of production will be required. Since the RFS limitations of biofuels from food crops such as corn have already been met, Kentucky's biofuels production will likely come from biomass resources through both forestry products and energy crops.

The technology for the conversion of biomass to biofuels is currently proceeding through the demonstration phase and entering commercialization. Florida and Georgia have invested in the Southeast's first two commercial cellulosic ethanol projects, and Tennessee is invested heavily in similar demonstration activities.

If Kentucky chooses to proceed with the development of biomass-based biofuels, approximately 10 million tons of biomass will be needed to produce 700 million gallons of renewable biofuels. With half of this requirement being available from existing forestry resources, almost 750,000 acres of new energy crops will be planted. While on the surface this number may seem daunting, energy crops for liquid transportation fuels would require only slightly over 5 percent of existing total farm acreage. Energy crops are currently in various developmental stages, and include native species such as switchgrass, eastern gamagrass and big bluestem along with sterile hybrids like miscanthus.

In addition to biomass for liquid transportation fuels, the more dominant and likely first use of biomass will be for co-firing in existing coal-fired power generation facilities. This would provide carbon offsets in a cap-and-trade system. It is also expected that numerous stand-alone biomass-fired generation facilities will develop across Kentucky if supporting policies can be developed. Since the technology for using biomass in a pulverized coal plant is still in the early stages of development, initial deployment of co-fired biomass is likely to occur in Kentucky's fluidized bed combustion facilities where biomass can be added at minimal cost. Experimental burns are in fact occurring in the Commonwealth today.

Should Kentucky be required to adopt a 20 percent federal RPS and choose to meet the RPS through in-state renewable energy production, almost 16 million tons of biomass will be used for combustion. Assuming half of the requirement is met by forestry, over 1,000,000 acres of energy crops will need to be planted, representing about 7 percent of Kentucky's total farm acreage. This may prove difficult if current federal rules continue to prohibit the use of biomass from forest plantations planted after December 2007.

The combined demand for biomass resources from Kentucky's forests and farmland for the generation of electricity and the production of biofuels approaches 26 million tons, compared to current in-state coal demand of 44 million tons. Such demand not only requires full productivity from Kentucky's forests, but provides farm diversification opportunity for 1.8 million acres, or 13 percent of total farmland. However, challenges exist in ensuring that Kentucky's forests are managed for sustainable production in order to meet the raw material needs of its forest industries, the state's renewable energy needs, carbon off-sets and other ecosystem benefits that forests provide.

It is estimated that biomass production can generate almost \$1.7 billion of revenue annually, much of which will be concentrated within rural communities statewide. When production is coupled with value-added processing of biomass to liquid fuels, an additional \$2 billion of income can be created. An opportunity of this magnitude for Kentucky to utilize its natural resources has not occurred since the rails were laid over 100 years ago to access Kentucky's coal reserves.

### **Next Steps**

In order to address the challenges presented by an RFS and RPS and to take advantage of the unique opportunities that Kentucky has to develop domestically produced renewable fuels and power, efforts must be consolidated under one set of goals identified in the Governor's energy plan; and those goals must be implemented by defined actions and complementary policies. It is, therefore, recommended that Governor Beshear appoint an Executive Task Force on Biomass and Biofuels Development in Kentucky. The Task Force should be composed of policymakers, stakeholders and consumers, and will become Kentucky's champion and voice for biomass and biofuels development.

The charge to the Task Force should be:

Facilitate the development of a sustainable biomass and biofuels industry in Kentucky that will generate prosperity in a carbon-constrained environment, and revitalize rural Kentucky by creating new jobs and strengthening local economies.

At a minimum the Task Force should accomplish the following, and report its results to Governor Beshear no later than November 30, 2009:

- Validate Kentucky's biomass production capabilities within a sustainable environment.
- Evaluate the status of energy crop and forestry biotechnology and genetics, and recommend a plan of action that allows biotechnology to support biomass production.
- Validate Kentucky's potential biomass demand.
- Evaluate biomass transportation and logistics opportunities, and recommend a course of action.
- Evaluate available business structures in Kentucky, including structures that allow direct producer ownership, and formulate plans of action that allow adequate capitalization of a new biomass industry.
- Facilitate economic impact analysis of the effect of a biomass and biofuels industry on Kentucky.
- Recommend legislative action that supports development of a biomass and biofuels industry.

The following membership is recommended:

Executive Director Roger Thomas, Governor's Office of Agricultural Policy, Co-chair

Secretary Len Peters, Energy and Environment Cabinet, Co-chair

Secretary Larry Hayes, Economic Development Cabinet

Senator David Givens

Senator Joey Pendleton

Senator Kenneth Winters

Representative Dwight Butler

Representative Thomas McKee

Representative Tanya Pullin

Commissioner Richie Farmer, Kentucky Department of Agriculture

Dr. Eric Berson, Chemical Engineering Professor, University of Louisville

Tony Campbell, CEO, East Kentucky Power Cooperative

Terry Cook, State Director, The Nature Conservancy

Dr. Nancy Cox, Associate Dean, UK College of Agriculture

Don Halcomb, Farmer, Simpson County

Mark Haney, President, Kentucky Farm Bureau

Mick Henderson, Agri-Energy Committee, Kentucky Agricultural Council

Dr. Kimberly Holmes, Associate Director, Land Grant, Kentucky State University

Dr. Bruce Pratt, Chair, Eastern Kentucky University Department of Agriculture

Dr. Scott Shearer, Chair, UK Biosystems & Agricultural Engineering

Richard Sturgill, President, Pine Mountain Hardwood Lumber Company

Betty Williamson, President, Kentucky Woodland Owners' Association

Staff:

Leah MacSwords, Director, Division of Forestry

Frank Moore, Director, Division of Biofuels, Energy and Environment Cabinet

Joel Neaveill, Chief of Staff, Governor's Office of Agricultural Policy

## APPENDIX II

# GOVERNOR BESHEAR'S EXECUTIVE TASK FORCE ON BIOMASS AND BIOFUELS DEVELOPMENT IN KENTUCKY

## Task Force Charge

Facilitate the development of a sustainable biomass and biofuels industry in Kentucky that will generate prosperity in a carbon-constrained environment, and revitalize rural Kentucky by creating new jobs and strengthening local economies.

## Task Force Work Plan

*All meetings will be held in the Capital Annex in Frankfort. Room numbers will be forwarded with agendas.*

### **1<sup>st</sup> MEETING: IDENTIFY PROBLEMS AND DETERMINE INFORMATION NEEDED** 1-5 PM, SEPT. 2, 2009

- Define problems and challenges
- Validate biomass production capabilities
- Validate potential biomass demand
- Initiate logistics analysis
- Initiate biotechnology analysis
- Initiate economic impact analysis

### **2<sup>ND</sup> MEETING: ANALYZE DATA AND FORMULATE PLANS OF ACTION** 1-5 PM, SEPT. 23, 2009

- Evaluate logistics opportunities and formulate a plan of action
- Evaluate biotechnology status and formulate a plan of action
- Review economic impact analysis
- Initiate analysis of methods of capitalization of a biomass industry
- Initiate analysis of available business structures including producer ownership

### **3<sup>RD</sup> MEETING: INITIATE LEGISLATIVE RECOMMENDATIONS** 1-5 PM, OCT. 14, 2009

- Evaluate methods of capitalization and determine potential capital requirements
- Evaluate business structures and formulate a plan of action
- Initiate recommendations for legislative action

### **4<sup>TH</sup> MEETING: FINALIZE LEGISLATIVE RECOMMENDATIONS** 1-5 PM, NOV. 4, 2009

- Finalize recommendations for legislative action
- Initiate final report

### **PRESENT FINDINGS AND RECOMMENDATIONS TO GOV. BESHEAR** 1-3 PM, NOV. 30, 2009

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